JOURNAL
AMERICAN WATER WORKS ASSOCIATION

Vol. 40 **JULY 1948** **No. 7**

Contents

All correspondence relating to the publication of papers should be addressed to

Harry E. Jordan, Secretary—500 Fifth Avenue, New York 18, N.Y.

ERIC F. JOHNSON, *Editor* — LAWRENCE FARBER, *Associate Editor*
DANIEL N. FISCHEL, *Managing Editor* — ELIZABETH P. MCSHERRY, *Associate Editor*

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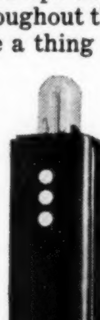

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Vol. 40 | July 1948 | No. 7

Public Relations Symposium

By R. B. Cooney, Norma Nelson, Don O'Reilly, Walter S. Byrne, M. B. Cunningham, Kenneth V. Hill, Ellsworth L. Filby and Harry E. Jordan

A symposium presented on May 6, 1948, at the Annual Conference, Atlantic City, N.J., by R. B. Cooney, Kelly Nason, Inc., New York; Norma Nelson, Public Service Commission of Halifax, Halifax, N.S.; Don O'Reilly, Public Relations Director, Washington Suburban Sanitary Dist., Hyattsville, Md.; Walter S. Byrne, Gen. Mgr., Metropolitan Utilities Dist., Omaha, Neb.; M. B. Cunningham, Supt. and Engr., Oklahoma City Water Dept., Oklahoma City, Okla.; Kenneth V. Hill, Partner, Greeley and Hansen, Chicago; Ellsworth L. Filby, Engr., Black and Veatch, Cons. Engrs., Kansas City, Mo.; and Harry E. Jordan, Secy., American Water Works Assn., New York.

Public Relations Thinking—*R. B. Cooney*

THE series of studies entitled "Silent Service Is Not Enough . . . ," prepared under the direction of the A.W.W.A. Public Relations Advisory Committee, is now completed. The chapter dealing with plant beautification and related topics will conclude the initial survey of public relations as applied to the water works job.

This, however, does not mean that the last word has been spoken on the subject. Rather, these studies represent a sort of stock taking. The real story began with the first handshake ever given a visitor to a water works plant. The real story will have no end. The real story will be the product of no one writer nor of any one committee, but will represent the sum total of all that is done to inform and influence the people in every community regarding the water supply and its importance.

The Association, through its activities at national and regional levels, will keep contributing to that story, but its essential development rests with the individual members. What the American public thinks about water service depends upon what the people in all the communities of the country think about the particular water service which they receive. No other public utility is so completely affected by local conditions, so completely subject to local attitudes.

The net result is that the water works public relations job must, to a very special degree, be a local effort. The studies which have been prepared are directed at the community level, with the goal of helping each member to conduct a more effective public relations program in his own backyard.

The studies have tried to accomplish this aim in two ways: First, they have endeavored to explain some of the factors which influence relations between the water works man and various segments of the public. Second, they have sought to present the kind of suggestions which would encourage the individual manager to take action, regardless of the size of his community or the local limitations imposed on him.

It was recognized from the outset that no set of general suggestions could prove of uniform value to all Association members. At the same time it was felt that without concrete examples the whole effort would possess little practical value. Accordingly, a variety of specific suggestions have been advanced. But they have been introduced as stimulants and not as pontifical dicta. It is their primary purpose to make the water works man think, "Well, maybe I couldn't do that—but, say, it does give me an idea!"

Another fact consistently recognized was the very obvious one that numerous water works men were already doing many of the things talked about. A number of the suggestions were, in fact, taken from reports by members of the Association, and, although credit was sometimes given, a more general acknowledgment is in order here. The advisory committee made many contributions of the utmost value, and one member in particular—Ellsworth L. Filby—gave of his time and thought to a degree which deserves a special word of gratitude. He not only eased the labors of the author with a variety of most constructive comments, but also caught more than one error which might have proved embarrassing.

It should be emphasized that it was not the purpose of these studies to amaze the reader with a Ripley-like array of things he never knew before. Instead, they have sought to bring together in orderly form a compilation of pertinent material, so organized that the relation of all the parts to each other and to the whole would be made clear. In their entirety, their aim has been to induce the kind of thinking that creates a planned, integrated, continuing public relations program.

Such thinking works from the inside out. It begins with the functioning of the business itself—with policies, operations and services. It looks at all undertakings to see how they can be utilized to influence public opinion. It explores all avenues of communication with the public to see how they can be most efficiently employed. It looks ever ahead, making sure that today's plans will yield all possible public relations benefits in becoming tomorrow's realities.

Recognizing Publicity Values

For example, suppose that the Hometown Water Works is going to construct a new filter plant. To the man who thinks in terms of public relations values, this opens a major channel through which public interest can be concentrated on the water works and its place in the community. From the project's inception to its completion, every step of the way is examined for opportunities to call people's attention to the job and its significance.

Beginning with the preconstruction phase, the public-relations-minded ex-

ecutive will seek, first, to set the stage for the opening announcement—perhaps arranging an important speaking date for the occasion. At the same time, he will make sure that his own employees hear the news and that public officials are informed. If some time is to elapse before work gets under way, he will save part of his ammunition to maintain interest during the interval. He may follow the first announcement with a press release on the design and landscaping of the new unit, accompanied by photographs of the architect's drawings. Or he may present these in a window display or transform them into a complete working model. He will issue stories concerning the opening of bids and the selection of contractors, and he may release at least one rather technical account, explaining the particular principle on which the new installation will operate. Perhaps he will send this as a special bulletin to doctors and health authorities or suggest its use in the high school science classes.

Meanwhile, he will start organizing his ground-breaking ceremonies—selecting speakers, inviting special guests, choosing the delegation to represent personnel, arranging for radio and press coverage, lining up photographers. He may want to mail a general announcement to his customers, or insert a special advertisement in the papers. With that event out of the way, he will keep an eye on the construction job as it progresses, seeing that photographs are taken of the various stages or perhaps arranging for a motion picture record. He will watch for interesting situations or incidents and call them to the attention of the press. He will maintain a continuing report to his coworkers and to interested community officials. And he will begin preparing for the actual opening of the plant.

He will start work on a descriptive folder to be passed to visitors and, possibly, mailed to customers. He may get the art classes of the schools to prepare posters inviting the public to visit the new unit—perhaps making it a contest, with judging of entries, a display of competing efforts and, of course, attendant publicity.

The actual opening will again be converted into a newsworthy occasion, complete with ceremonies, speeches, distinguished guests, photographers and even a luncheon. Then there will follow a week or two of special open house, with invitations extended to civic clubs, community groups and business associations. By the time the new filter plant has settled down to routine operation, most people in town will at least possess a dim awareness that the water works has done something to improve service.

Now it is granted that the service would have been just as effectively improved without any of this fanfare. Is the public relations campaign, after all, worth the effort?

The answer lies in that apathy—more discouraging than opposition—which so often greets the water works man when he needs the public actively on his side. The one thing in which people are most interested is themselves. To break through that wall of self-concentration is a major job achieved only through consistent effort, utilizing every implement available. Public relations thinking and planning endeavor to make the fullest and most efficient use of such implements.

These public relations studies have tried to explain what the implements

are, what they will do and how they can be employed. The studies have sought to convince the water works man he could make use of at least some of these implements, regardless of the size of the community or the complexities of the local situation. And finally, the studies have attempted to demonstrate that the effort and thought and time involved in conducting public relations represent a legitimate and important part of the water works job.

Halifax Public Relations Program—*Norma Nelson*

THE use of the term "public relations," and of the procedure developed under it, is comparatively new. The fundamental principles underlying public relations, however, have been practiced to some extent, in one form or another and under various names, for centuries. These principles are too well known to require any elaboration in this paper. Stripped of the mass of phraseology usually employed to define the term, public relations is essentially a compound of the homely, simple virtues of neighborliness, kindness and community spirit; cooperation and understanding between the general public and the industrial or other undertaking; and the procedures, methods and processes adopted to acquaint the people with the manner in which these principles are put in practice.

It is the purpose of this article to say something about the manner in which these underlying principles of public relations have been carried out by the Public Service Commission of Halifax.

The Public Service Commission of Halifax is a fairly young organization. It was founded by an act of the legislature of Nova Scotia in 1944, to manage and control the water system of Halifax, which was formerly operated directly under the City Council. The commission was fortunate in being headed by officials who realized the necessity of good public relations, as well as of good relations within the employee group. With the idea in mind that one depends to a large extent on the other, the Public Service Commission, ever since its founding, has recognized the importance of public relations and has carried out an extensive public relations policy.

Credit for the conception and details of the policy is not all due to the officials of the commission, because vast use was made of the material and ideas contained in the A.W.W.A. Public Relations Studies. The sprite, Willing Water, was loaned by the A.W.W.A., and R. B. Cooney's suggestions have been the guiding hand in the commission's program.

Although basic principles are widely recognized in public relations programs, it is necessary that they be fitted into the local picture and that adjustments be made to meet the needs of the particular organization to which the program is to be applied.

Halifax is a comparatively small city with a population of 90,000. It is an old city, steeped in tradition and custom, and this year it is celebrating the one hundredth anniversary of its water system. The citizens of Halifax are characteristically cautious and conservative. Therefore, before any radical changes in policy could be undertaken by a publicly owned organization, a careful study was necessary to ascertain the possible effects on the citizens and ratepayers.

Personnel Training Program

When the first bright orange trucks and service cars of the Public Service Commission, with Willing Water's pic-

ture and breezy messages painted on them in royal blue, went dashing around the city, there was considerable curiosity about the work they were carrying on. In order to make sure that the operators and crews who accompanied these trucks held up a fine example of courtesy and efficiency, it was necessary to begin a comprehensive personnel training program within the commission.

As a result of this training, and the energetic efforts and understanding of the officials, it can be asserted that the public relations program is today carried on by all of the 200 commission employees, because each of them is looked on as a person of high efficiency and courtesy. This was a wonderful first step for a good public relations program, and an excellent way to gain the confidence of the public.

The meter readers, who have the closest contact with the citizens through the daily readings in their homes, make an excellent impression. They are courteous and friendly, and their uniforms are well known in Halifax. The service crews who look after emergency calls and other repairs, are a competent and cordial group, and many an impatient consumer has been so impressed with the pleasant and efficient way these men go about their jobs that the inconvenience of the moment has seemed much less serious.

The office staff—which exemplifies the Public Service Commission motto of "Efficiency With Courtesy" to the utmost degree—is held in high regard in the city of Halifax. Many an irate customer who believed his bill was higher than it should have been has left the offices in an easier frame of mind after contact with the patient understanding of those whose duty it is to collect his money.

Public Education Program

All this good will between the people of Halifax and the commission was not built up quickly. It required a long program of education, which is still going on. During the past year, when the commission was preparing for an increase in the water rates in the city, the public relations work was of particular importance.

The City Council is an important section of the public with which it is necessary to promote good relations. Although the commission is incorporated by an act of the legislature to maintain and operate the water system, it is still owned by the city and all the capital expenditures must be approved by the City Council. At times this may cause complications if the actions of the commission are not understood by the aldermen or their electors. People cannot understand why a spanking new piece of pavement has been torn up; they cannot understand why they are not allowed to dump their garbage on the watershed area when they are out driving; or why they are forbidden to cut a Christmas tree from the lush growth on the watershed.

Press Relations

The commission advertises weekly in the local newspapers to try to explain to the taxpayers why its actions are necessary. Newspaper ads are run in the spring and fall, in preferred positions, showing Willing Water stumbling over storm doors and other debris, asking property owners to make the way for the meter reader easier by not putting obstacles in his path to the meter. Detailed explanations are given at the end of each year about the work accomplished during the preceding twelve months. Any change of hours or departure from regular schedules is outlined in an ad in the papers.

In addition to the ads, which are paid for, the newspapers have been most generous in giving publicity to the commission and its staff. A close friendship is maintained with the reporters and editors of both local papers. They are invited to staff parties and copies of the staff paper are sent to them. The newspapers have quoted directly from the staff paper items of interest to the community. Care is taken that neither paper is given an exclusive story. If there is something of particular importance, both papers are called and asked to send their reporters. As a result, the commission has enjoyed long columns of very valuable advertising, which has given the public information that could never have been furnished by paid ads.

Radio Talks

The value of radio has not been overlooked, and the same cordial relationships which have been built up with the press exist between the radio stations and the commission. During the past winter, preceding the application to increase the water rates, it was felt that an extensive educational program might be carried on so that the public would know the water commission.

The services of one of the local radio stations were made available for a series of four broadcasts at 8:15 in the evening on consecutive nights, so that the four ranking officials of the commission could each give a fifteen-minute talk. The series started with the General Manager, who described the commission, its organization and history; the Chief Engineer then told about the Engineering Department and its activities; the Office Manager discussed the general administration of the accounting department—billing and the like; and the final talk was given by the Assistant Engineer, who told about the treatment of the water and about the outside work of the Engineering Department.

These broadcasts met with much greater enthusiasm than was anticipated. Both from the Commission's point of view and from the station's, they were a valuable bit of public service. It is hoped during the next year to present a similar series and to obtain the facilities of the other local station for a forum discussion by the General Manager of the water system and the managers of the other four public utilities in the city. Time for such programs is given by the radio stations without cost.

Public School Project

The commission tried something this year which is believed to be quite new in public relations work, especially when conducted by a water utility management. Believing that the school children of today are the ratepayers of tomorrow, it seemed desirable that they should be familiar with their water service. Also, it was known that children are good publicity agents, and that what they saw and heard would certainly be taken home to their parents. In conjunction with the Vocational Guidance Department of the city school system, an educational project was carried out to acquaint the pupils with the water utility.

Two female employees of the commission spoke over the radio about their jobs—billing and cashier work. The secretaries to the Office Manager and to the Chief Engineer have also given talks. These programs have a listening audience of about 20,000, including the surrounding districts, and therefore bring the Public Service

Commission to the attention of many people.

In addition to the broadcasts, tours of the commission offices and plants were arranged for high school students. Those interested in the office administration came to the offices in groups and were conducted on tours which lasted around two hours. They were received by representatives of each department, who explained the work they supervised. The students' enthusiasm was really tremendous, and in the career books which they prepare during the year, some of them have written about individual Public Service Commission employees, whom they met on their visits, as outstanding career people. It is very flattering to receive such recognition from the high school students of the city.

Because a number of young men and women were interested in becoming engineers, chemists and machinists, the commission arranged a tour of the outside works and plants for them. The tour occupied one Saturday morning, and transportation was provided by the commission. Certainly no trip on an excursion boat ever rivaled in excitement the thrill of those young people touring the city and the watershed in the commission's big trucks. In connection with the guidance program, the commission is offering prizes this year for the outstanding career books in the engineering and stenographic fields.

Good Will Through Public Service

Many public services have been rendered by the commission staff. During the explosion in Halifax in 1945 at the naval munitions storage depot, the maintenance crews organized and supervised part of the evacuation from the city. Commission trucks supplied water to those who were forced to leave their homes for the clear spaces during the night. These trucks also assisted in moving people back to their homes when the danger was over. Each Christmas Day commission trucks and drivers are loaned to the Salvation Army to distribute Christmas cheer to the needy.

There is a particularly interesting story about Christmas of 1947. One of the operators was stormbound at the pumping station for two days before food and a relief operator could reach him on snowshoes. This man was pictured in the press as a great hero enjoying Christmas dinner with his family two days late, and he was the subject of a complete fifteen-minute story over the radio by one of the local commentators. Another commentator has devoted a full program to a story about the commission, with particular reference to the work of the crews who kept the fire hydrants clear every day during the heavy snow of the past winter.

Staff Social Activities

The members of the commission staff are exceptional and each one does a public relations job on his own. There is a staff paper, produced entirely by the employees. Several times during the year Willing Water is host at a party or a picnic organized by the Employees' Social Club and attended by the commission members as well as the executives of the commission, and their wives. The mayor and the aldermen, along with their wives, also attend these parties, which have made Willing Water famous as a host.

The commission's General Manager is very much in demand, both in the city and throughout the province, as a speaker at service clubs and boards of trade. The other executives are also

accomplished speakers, as well as being champion golfers, curlers and athletes generally. One member of the staff recently directed the local figure skating club's annual carnival, while another has been pictured in the local press displaying some of the fine mink he raises in his spare time. The female members of the staff are represented on almost every active group in the city.

The commission looks with favor on the outside activities of its employees, because when an individual is highly regarded for his contribution to the life of the community, the organization by which he is employed is kept before the public, and interest and regard for it maintained in the minds of the citizens.

It may be gathered that the author considers it a real privilege to have a part in both personnel and public relations work, especially in an essential public utility. To quote the proverbial Irishman, "There's nobody so interesting as people." No degree of material success can make a job worth while which does not contribute to the welfare of a community, especially in mutual good will; and which does not give high priority to the happiness and opportunities for service of the members of the staff.

Promoting Good Publicity—*Don O'Reilly*

EVERY phase of the public relations program is important. Whether one is more essential than another may be a subject for controversy, but, in any event, the chain is only as strong as its weakest link. The part of the public relations program which this paper will discuss is the promotion of publicity.

The first step in promoting good publicity is to arouse the interest of the newspapermen in the activities of the water department. A water works which has figured in the news to any extent does not have this problem, but those utilities which have been giving "silent service" must create interest.

Value of Friendly Newsmen

It is not hard to get acquainted with the reporters who are assigned to the area in which the utility is located, because it is their job to know people in all walks of life. If they once discover that a water works official is a source of news, he will have little trouble keeping their friendship.

Most newsmen are interested in doing an impartial and objective reporting job. But the fact remains that a reporter can slant a story either way—pro or anti. In fact, to make them interesting, most stories must be slanted one way or the other, because the so-called "middle of the road" stories lack "punch." Reporters are human, and though they don't "color" their stories—of course, there are some possible exceptions—or editorialize, they do lean toward the cause in which they believe. An example or two will illustrate this point.

The author was working on the Washington *Post* when he received a call from a group of citizens who were peeved at the Washington Suburban Sanitary Commission. They lived in one of the many new developments which have sprung up so rapidly in the national capital area. Their complaint was that a near-by stream was polluted by a discharge of sewage, and they had erected a large billboard warning that the stream was unsanitary.

After visiting the area and talking with the residents, the author had sufficient facts and could easily have written a story critical of the commission. Although he had no interest in the commission at that time, the engineers in charge had always been cooperative and had tried to be helpful in every way. The author therefore phoned the commission and was given considerable additional information. It was explained that the development was growing so fast that emergency steps had to be taken until such time as the costly trunk sewers could be constructed; the commission was as dissatisfied with the situation as were the residents of the area.

Thus, instead of a story critical of the unsanitary conditions, the article, which ran almost a column long, told about the commission's plans to eliminate stream pollution, not only in that particular area, but in other sections as well. In this way, the officials' efforts at cooperation later paid off by turning a possibly critical and harmful story into one which was constructive and beneficial.

About a year and a half later, the author was engaged as the Washington Suburban Sanitary Commission's first Public Relations Director. Needless to say, he did not have to get acquainted with the newsmen, and their friendship proved invaluable when a tragic incident occurred. A steel company was building an elevated tank for the Sanitary Commission, and the Washington newspapers did feature stories on it. The *Post* had a particularly unusual and effective photograph showing one of the workmen on the spiral ladder. The story, of course, centered around the Sanitary Commission, with the builders getting a little credit along the line. Unfortunately, a week later, the workman in the photograph suffered fatal injuries in a fall from the tank, and local firemen were summoned in a vain attempt to save his life. This spelled news in any man's language.

The author received calls from the reporters and gave them all the facts available. It was an unavoidable accident, and, though most unfortunate and regrettable, there was no thought of covering it up. The *Post* carried the story on page one and repeated the week-old photo of the workman on the circular ladder. However, where a week before the story had been concerned largely with the Sanitary Commission, this article told about the tank being built by the contractor and ended with the sentence: "The tank is being built for the Sanitary Commission." This was the only mention of the commission in the whole story. The manner of treatment of both stories by the reporters was due to their friendship for the commission.

Just to show how a story is usually "slanted" one way or the other, it could read, "Hundreds of families were deprived of water service for two hours this morning . . . ," or "Water service was back to normal at noon today after a midmorning interruption. . . ." Not a great deal of difference, but which version would be preferred by the water works involved?

Fair Play

After the acquaintance of the reporters has been made, it is still necessary to play fair with them if their friendship is to be kept. They must be treated alike, and, above all, with complete honesty. No information should be withheld or inaccurate statements

given. Even when it is not possible to talk for publication, the reporters should receive full details "off the record." Newsmen are proud of the tradition that confidences are held inviolate.

Many times stories break right on a reporter's deadline, and if he knows he can depend on an official, he will accept his statement without further checking.

It is far better to be able to stop an inaccurate criticism from appearing in print than to have it appear today and deny it tomorrow. Many who read the original story will miss the denial; half of those who read both will believe the first story; and those who see only the denial will let their imaginations run wild—and then a really bad situation will result!

Press Releases

Newspapers may object to the reams of press releases that flood their offices daily, but there are press releases and press releases. The criticism is levelled at those in which the "meat" of the story is buried—frequently in the last paragraph. Often, too, there are hidden meanings in some of the stories, or else the facts are only half told for various reasons.

The author has found that press releases written in regular newspaper style are very acceptable. These should be delivered to the reporters themselves rather than sent to the newspaper city desk. A press release will not usually be taken at face value unless the reporter knows the writer and has confidence in him. Technical phraseology should be avoided.

It is a good plan to send releases out on regular newspaper copy paper, triple spaced, with plenty of room at the top of the first sheet. The reporter will frequently tear off the commission letterhead, type his own name on the release and turn the copy in as is. This may sound as if the newsmen are lazy and are taking the easy way out, but it must be remembered that when a reporter is responsible for all the news in a whole county—approximately 150 square miles—he is usually kept busy. For example, the last week that the author worked on the *Post*, he covered a murder trial in the court house, followed another murder investigation at police headquarters, including an eight-state search for the murderer, and still kept in touch with all the routine news. What a blessing press releases would have been then!

Releases should tell the whole story in the first two paragraphs, which must nevertheless be kept short. If it is bad news, such as a rate increase, there is no sense in burying it beneath a long dissertation on the higher cost of production, because when it gets into print, it will start like this anyway: "Local water consumers will be faced with a rate increase July 1." The reasons for the increase will follow.

Many ways of getting good publicity are outlined in the A.W.W.A. Public Relations Study No. 6, and it is recommended that these excellent suggestions be followed. The author has not attempted to elaborate on these methods but merely to emphasize and illustrate some of the highlights.

Every area is faced with a different problem. The Washington Suburban Sanitary Commission has operated efficiently for three decades—so efficiently that people knew little about it. In fact, many were amazed to learn that it is not privately owned but is a

municipal operation. A very public-relations-minded engineering department, however, is helping the author use the schools, the radio and the newspapers to tell the commission's story. As far as the commission is concerned, service comes first, but "Silent Service Is Not Enough."

Use of Paid Advertising—*Walter S. Byrne*

WATER service is so uniformly good that it is taken for granted and the public "never misses the water till the well runs dry." It often takes an accident or interruption of service to force the utility or its officials before the public eye. Although the public itself may be partially to blame for this condition—for example, through the passage of restrictive legislation—in the main, the fault lies with water works men because of their absorption in the technical phases of the industry and their too frequent contempt for the problems of public relations.

The public is entitled to know the facts of the water business. Its service and product are essential to public health and safety. Its financial needs and problems are those of every individual citizen and the community as a whole. The fact that the majority of the plants are publicly owned and operated is no reason or excuse for failure to conduct the utility on an efficient and businesslike basis, making use of such methods and media for the dissemination of information as judicious private ownership and operation would employ.

On the principle here involved, the Supreme Court of Nebraska said in its decision of a suit brought to enjoin the Metropolitan Utilities District of Omaha from selling gas appliances:

> We think the correct rule is: If a municipal corporation legally acquires a public utility plant, with the right to operate it for the benefit of its inhabitants, it would likewise acquire by implication the right to do all the things that a private owner might do in order to furnish economically and efficiently to the citizen the product in which it deals.

Of course the water works operator is as much bound by the words "for the benefit of its inhabitants" and the words "economically and efficiently" as he may feel emancipated by the general theory of the decision, but that is the nature of practically every responsibility he has. In any event, the decision emphasizes the importance of the problem of using paid publicity or advertising and dismisses the idea that advertising is an "end" instead of a "useful means" or tool which may or may not be "economically and efficiently" used.

Consulting Experts

There must first be a necessary and beneficial purpose to be accomplished; this being so, it is natural to progress to the use of economical and efficient media, whatever they may be. The infallibility of the water works operator alone to decide the most efficient medium is dubious. Almost everyone disclaims being a public relations and advertising expert, but at one time or another makes opinionated and quasi-authoritative pronouncements, just as the author is doing at present. There are experts, however; at least, there are men and organizations in almost every city who make a good livelihood working as public relations and advertising counselors. Almost all offer a

consulting service. The individual utility should submit its problem to one of them in its entirety, presenting in complete detail the nature, urgency and purposes to be accomplished. They should be taken into confidence, especially if a selfish motive can be charged.

An expert's opinion may perhaps be that the utility's cause would be hurt more than helped by the use of paid publicity. It may be that one advertising medium would be advisable or useful and another detrimental. The Metropolitan Utilities District of Omaha, Neb., found radio, a medium it uses regularly, wholly unadapted to one of the largest publicity campaigns it has ever conducted. Handbills, on the other hand, though never before employed, were most essential and effective. An advertising counselor may be presumed expert in evaluating media for a special purpose.

To trespass once more on the expert's domain, in the author's opinion, no beneficial results can be expected from the use of a reputable newspaper's space for the purpose of favorably influencing the paper's editorial and news policy. Generally speaking, the effect will be the reverse and most often these days the publisher is doing the advertiser a favor when he permits him to use his precious space.

Some years ago one of the nation's leading authorities on publicity told a prospective utility client: "Ninety per cent of my fee will be for telling you when to say nothing; the other 10 per cent will be for telling you what to say and when to say it."

Advantages of Paid Ads

Naturally, the question arises: if a story has news value and is important to the whole community, why pay for having it published? In the first place, the ability of the water works man to judge newsworthiness is doubtful; and, second, the author's experience has been that misfortunes and accidents are most newsworthy in the editor's opinion.

Limited observation leads the author to believe that the water works industry is the beneficiary of less indirect and favorable paid advertising than any other type of utility. Merely scanning a popular magazine will turn up evidence of the help that transportation, power and communications utilities are receiving from both manufacturers and their own trade associations. On the other hand, in ten years the author can remember only two advertisements in national magazines directed to the public about the water industry. One was by Monsanto urging the public to demand the use of its product or process by water works. The other was the series of well-written and helpful ads published by the Cast Iron Pipe Research Assn. These built confidence in water works officials, construction and service.

Paid advertising in appropriate media is a completely controllable tool. The advertiser may say what he wants when he wants and—most important—in the way he wants to say it. It is not necessary to rely on someone else's interpretation of fact.

Dealing With Public Officials—*M. B. Cunningham*

THIS paper will discuss briefly the subject of relations with public officials, especially from the standpoint of a water department superintendent, who has to deal with elected officials and, perhaps, with a city manager, a board, a commission and important citizens.

Dealing with public officials becomes more realistic and effective when first

consideration is given to rendering courteous service to the public. If such service is maintained, and intelligent and timely information about what is going on in the water department is released, public officials are more inclined to listen to comments and recommendations by the department. "Silent Service Is Not Enough."

From past experience, the Oklahoma City Water Dept. bases its public relations information, like construction work, on plans and specifications. It respects the laws of human nature by striving to design information from the point of view of the other fellow, not always from the department's outlook. After all, the objective is to inform and influence other people, to get their cooperation and assistance and prevent misinterpretation.

Public officials are anxious to give a good accounting of their service to the people. The Water Department makes their position easier, as well as its own, by keeping them advised of its needs and accomplishments, and—most important—by presenting suggestions and carefully planned recommendations on the problems which confront it. In addition, copies of employee bulletins are sent to the city manager, the mayor and the city council.

A water superintendent requires teamwork to carry out his public relations program. No other group is likely to be as helpful as public officials. It is necessary for the water superintendent to find a way to get them on his team, especially those with whom he works and on whom he depends for approval of his recommendations.

Public officials should be informed of important facts in advance of news releases, particularly if they can expect to be questioned about the subject. Failure to do this often results in conflicting statements, and what was intended as good publicity turns out to be bad.

Alertness in publicizing future difficulties can avoid needless complaints. In 1947 the Oklahoma City Water Dept. was confronted with a problem which affected an entire section of the city where development had been so rapid that a new force main was needed, representing a $500,000 investment. Early in the spring the department realized that low pressures would be inevitable during summer peak loads. Everyone concerned, including public officials and consumers, was informed in advance why low pressures would occur and what construction was proposed as a remedy. Consequently, people understood the problem and were considerate and tolerant of it. Public officials were pleased because they did not receive a multitude of complaints.

News is perishable and should be made short and interesting. This applies equally well to reports made to public officials. If the problem is stated at excessive length and no solution or suggestion is offered, or if a glance is enough to tell that the report is dull and lifeless, it will not be read. On the other hand, if it is interestingly presented and includes a summary containing sound proposals and solutions to problems, the report will be given proper attention.

There are a number of principles which the author has found helpful to keep in mind: (1) three important viewpoints must be considered—the public official's, the water works executive's and the public's; (2) telling the truth adds to the reputation of the department; (3) photographs should be made to tell the story; (4) public relations programs should be coordinated with those officials who determine objectives and policies; (5) it

pays to be fair, cooperative, sincere, friendly, alert, accurate, appreciative and human; (6) it is unwise to play favorites, complain or ask favors; (7) full use should be made of A.W.W.A. public relations material.

In the author's opinion, the degree of success which may be attained in dealing with public officials depends largely on planning and on the intelligent application of these and other principles.

Selling a Project to the Public—*Kenneth V. Hill*

THE people of Moline, Ill., are water-conscious. They are especially concerned with tastes, odors and hardness; and the water filtration plant and its product are of interest to the average citizen.

Moline is a rapidly growing industrial city with an estimated population of approximately 40,000. About 60 per cent of the total water sold is used for industrial purposes. Water has never been sold at Moline for less than the cost of production and distribution. To help meet the expense of constructing and operating proposed improvements in the system, a new rate schedule has been enacted providing for a 33⅓ per cent rate increase for customers inside the city, with no change for those outside the city limits.

The present water works superintendent, A. E. Anderson, is rounding out thirty years of service, during which he has been responsible for and has guided the development of two major improvements to the water works: the construction of a 5-mgd. filter plant in 1932, involving an expenditure of about $350,000; and the present improvement to the filter plant, which comprises an increase of 50 per cent in capacity and conversion to softening at a cost of about $700,000, conversion from steam to motor-driven pumping at a cost of approximately $400,000 and a new intake and shore well.

Both the 1932 improvement and the present one, bids for which were received on May 13, 1948, have been financed by the issuance of water revenue bonds. In 1932 the contractors were paid in bonds which they accepted at a discount.

The bonds issued for the new work bear 2.93 per cent interest and are to run for a period of twenty years. At present there are approximately $205,000 worth of noncallable bonds outstanding on the 1932 issue. These are scheduled for retirement at the rate of $15,000 to $25,000 per year up to 1958–59.

In order to take the best advantage of increased earnings, the new bonds maturing in the year 1977 are callable December 31, 1953, and those maturing in the years 1970–76 inclusive are callable December 31, 1958.

Preparatory Steps

The steps taken in preparation for the present project were the usual methodical and careful procedures which have characterized the conduct of the affairs of the water department. They included:

1. Appointment of a citizens' committee to work with the water committee of the City Council. Technical personnel of the principal industries were included in the citizens' committee.

2. Selection of engineers to investigate and report on the immediate and foreseeable future needs of the water system and their estimated cost.

3. Employment of engineers to make a study of existing water rates and their adequacy or inadequacy to finance the construction and operating cost of the proposed improvements.

4. Consultation with financial houses and special bond attorneys on the adequacy of the rates in the proposed revised schedule to cover increased operating costs and debt servicing.

5. Word-of-mouth canvassing of the industries and citizens of Moline about their attitudes toward the project, plus contacts with the Chamber of Commerce and various service clubs.

6. Passage by the City Council of the revised rate schedule and the necessary ordinances to cover the issuance and sale of the revenue bonds.

7. Sale of the bonds.

Making Friends of Customers—*Ellsworth L. Filby*

A WATER utility is a service institution—built and developed to supply essential service to the people of a community or area. The ownership of the utility may be public or private, but both types depend for their success on how well they satisfy the requirements of their customers. A water utility has only two things to sell, service and water. If it fails to satisfy its customers, it has failed to sell half of its potential product.

In a monopolistic utility, where there is but one service which can be purchased, there often develops a lackadaisical attitude of "So what? If you want water, you buy it from us—or you don't get it." This is the old "public be damned" attitude that has brought about governmental regulatory measures and creates socialistic trends. In a developing country, customers were the least of the worries. The changed status of the customer today, however, is indicated by the message on a framed placard which hangs in every office of the St. Louis–San Francisco Railway System:

> A *customer* is the most important person who calls on us. . . .
>
> A *customer* is not someone we favor by serving; but the one who favors us by permitting us to serve him. . . .
>
> A *customer* is not someone who depends on us; but the one on whom we depend. . . .
>
> A *customer* is not an interruption in our work; but the purpose of it. . . .
>
> A *customer* is not someone to argue or match wits with . . . nobody ever won an argument with a customer. . . .

This is a far cry from the days of Jim Hill, but it was only yesteryear when courtesy was the forgotten art in stores, when it was take it or leave it, the price is so and so. Today utilities—railroads, gas, electric and communications—have entire departments working to be ready to serve the instant they are needed. All utilities are alert in helping to develop their territory and aiding the people and business in it so that they in turn may grow; the utilities are selling service primarily and a product second.

Water works customers can be friends! The ways to accomplish this are easily found, but it is a step forward that takes planning plus a willingness to go that "extra mile" to make a friend. The utility organization must be keyed to make friends and not function as an automaton, from which, when certain buttons are pushed, the stereotyped answers come forth, and to which the customer is just a "nec-

essary evil" to be treated with frigid contempt.

Treatment of New Customers

Normally customers have few contacts with the department; many only two—when they sign up for service and when the final accounting is made. They seldom see the meter readers; they get a bill by mail which they pay by check; they have no idea how the wheels go round and often do not care, unless an attempt is made to interest them.

The first contact is when the new customer comes into the office to have the water turned on. Here is the initial opportunity to make a friend. A pleasant, neat receptionist should ask courteously, in a nicely modulated voice, "Can I be of service to you?" The stranger should not have to look around in bewilderment and be forced to inquire where to apply. How easy and pleasant to have someone volunteer to help, to see that the new customer is seated comfortably at a desk designed to allow his knees to extend beneath it—a desk designed for his comfort as well as the comfort of the employee. At such a "one-stop" desk, after a moment of greeting, the essential data can be obtained, a deposit secured if required, and the necessary charges made for the service tap. All the business is thus transacted at one spot, in a quiet place which is air conditioned for comfort and convenient of access—on the first floor or street level, if possible. A brief explanation of the discount or penalty system, the period of billing and the like can be given in a few moments, and as a parting gesture the new patron may be presented with a handy illustrated folder containing a description of the utility, the rate schedule and other pertinent information, as well as an invitation to visit the plant. Special folders can be designed for the various categories of customers—domestic, commercial and industrial—giving data of value to each. Why try to explain sprinkler fire service rates to a domestic customer when the sprinkler he thinks of is probably for use on the lawn? A few pleasant remarks on parting: "The water will be turned on in the morning if it is convenient for you. . . . We hope you will like our community and that you will take a part in making it a better place to live. . . . We are here to serve you—call on us," and the department has taken the right step in making a friend of the new customer.

The "one-stop" desk can also be the complaint and adjustment department, where simple services that create friends instead of enemies can be rendered to the patrons.

Service Cutoff

When customers close up the house but forget to tell the water department they are going away, the meter reader should function as a human being and write "out of town" on the slip. If a bill has not been paid, past performance should be taken into consideration instead of treating all alike and cutting off service. Notices of "past due account" should be courteously phrased and not brusquely admonish the customer to pay up or be cut off. A few more printed words—a presumption on the part of the department that the bill has been lost or overlooked—or perhaps a phone call from the "service department" to the effect that the delinquent date is close at hand, constitutes a friendly gesture of neighborly helpfulness which is preferable to a cold, businesslike attitude. These sim-

ple things make up that little "extra" service so much appreciated by everyone.

The meter readers, cashiers and other departmental employees who may have contact with the customer should be neatly attired, greet patrons pleasantly and render personalized, efficient service.

"The customer is right" has proved to be a good business slogan to follow. The staff soon learns how to handle customers; how to listen to their complaints, their trials and tribulations; and how to sift the wheat from the chaff. Customers are human beings who make mistakes, just as some departments occasionally err. And if the utility is in error, it should be openly admitted and the necessary amends made. The public should be taken into confidence because an enlightened community will always cooperate with a management it can trust.

Flexible Procedure

Everyone knows that it is desirable to have flexibility built into the plant and system. Flexibility, plus the "factors of safety" so commonly used by water works engineers, has enabled utilities to carry on through years of war, shortages and depressions. Customers must be treated with a like degree of flexibility, not in accordance with rules which may have been applicable in the horse-and-buggy days or which were adopted because another locality found them satisfactory.

Sometimes customers are requested to sign an acceptance of "applicable rate schedules and rules and regulations now or hereafter in effect." It is indeed a truism that an American can be persuaded to sign anything; but while many will sign anything to get water, is it not a sad commentary on the intelligence of the customers to ask them to agree to rules as yet unwritten?

It should be made easy for customers to fulfill their part of the contract. In some cities the gas and electric utilities have branch payment offices, and the phone bill can be paid at the neighborhood bank. Yet to pay the water bill it is necessary to go downtown to City Hall. Of course, it is possible to mail a check, but many small customers do not have a checking account. This difficulty could be eliminated by a cooperative program with the local banks or by having a deputy collector at the police station. And if a customer owns his own home and has established satisfactory credit in the community, he might be allowed to prepay his bill, based on last year's consumption. This would require only one trip to City Hall instead of four, six or twelve, and the saving of time and expense will build better customer relations.

Periodic Reports

Municipal utilities are owned by the public—a fact that is too often forgotten. Private concerns, from the giant oil corporations to the local stock company, all render yearly reports to their owners on business, earnings, expenses, future plans and the like. Yet very, very few municipal water works give an account of their stewardship. Pride of ownership cannot be created overnight! When public support is necessary, it is impossible to capsule all the utility's accomplishments, needs and requirements and jam them down the throats of the owners—they are likely to gag. How much easier to acquaint the public month by month and year by year with simple, factual

reports readily understood and attractively presented! Certainly, many reports are never examined and statistical compilations merely use up library space, but some are read and studied. They work for the utility just as any other tool in the department.

Signs are silent salesmen and can serve the utility well. Messages on construction barricades might read: "Building a Better Jackson!" or "For Better Fire Protection." The public can be made aware of what the water works is accomplishing, by a poster such as "City of Xville—14-million-gallon clear water reservoir—a reserve for peak demands—constructed from earnings [*or* through a bond issue]. The Water Department works for the progress of Xville."

"Silent Service Is Not Enough . . ." has plotted the course. It is truly a most excellent guide and the last section is the best yet. The author hopes the series will not be discontinued, for it has been excellently constructed and presented. Water works men must keep everlastingly at the job of public relations because it is so easy to slip back into routine.

Progress in Public Relations—*Harry E. Jordan*

THIS symposium on public relations activities is a milestone in the progress of the Association. It provides evidence of the progress made in the field by members who have taken some measure, at least, of their inspiration from the studies in the series "Silent Service is Not Enough. . . ."

The Board of Directors and the A.W.W.A. staff await with the greatest of interest whatever suggestions the members might make to outline the course to be followed in advancing the good work already done. Will you give us your counsel?

One thing we have learned which should have some bearing on future action. It has been clearly demonstrated that, just as water works men failed to gain the public support they deserved, so also do public servants generally appear not to understand or apply the otherwise characteristic American method of promoting approval and sustained public support for their efforts.

Thus, although water works men will, as a result of the work the Association has done, make progress in building good will, they must remember that even greater progress would result if the other municipal technical services, and even the administrative services, were actively aware of the propriety of planned effort to develop and maintain the affirmative support of the people they serve.

Too many American citizens are cynical about municipal government and municipal public service. Is it not time to demonstrate that loyalty is deserved rather than cynicism?

National Policy on Water Resources

Committee Report

A report of the Committee on National Water Policy, presented on May 4, 1948, at the Annual Conference, Atlantic City, N.J., by Committee Chairman Abel Wolman. The other committee members are A. P. Black, E. Sherman Chase, Samuel B. Morris, N. T. Veatch and W. Victor Weir. This report has been accepted in principle by the Association's Board of Directors, and the statement on p. 697 has been adopted as an official declaration of A.W.W.A. policy.

THE United States, which now comprises about 145,000,000 people, covers an area of more than 3,000,000 square miles and is richly endowed in many sectors with surface and underground water resources, but these must be intelligently conserved and used. To state that such a country as this is a far cry in its complexities and in its requirements from the one which established the rules of the game for a federation of governments in the late eighteenth century is to put it mildly.

In the public water supply and sewerage fields, the nation is confronted with the probable expenditure of somewhat less than eight billion dollars during the next five to ten years.

In the Missouri Valley area over two billion dollars of construction is contemplated under the Pick-Sloan Plan. If the St. Lawrence Seaway is ever constructed, it will cost between 700 and 1,000 million dollars. During the current fiscal year alone, the U.S. Corps of Engineers may spend almost 300 million dollars for flood control work. The Bureau of Reclamation anticipates expenditures for the next five to ten years well in excess of several billion dollars, with recent congressional approval of a $195,000,000 budget, one of the largest in its history.

This bare sampling of the prospect in water development should give the discerning citizen some inkling of the kinds of perplexing problems which plague the states and the federal government in connection with the allocation of water, the financing of projects, reimbursal programs, jurisdictional administration and—by no means least—political jockeying for power and responsibility.

Conflicting Opinions

The Committee on National Water Policy is confronted with a simple question posed by the A.W.W.A. Board of Directors: "What should be the position of the American Water Works Association on national water policy?" The question, of course, is far simpler than any conceivable answers might be. No two groups of people are in accord either on the underlying philosophy of control or on any of the myriad of details of its imposition. Many advocates of states' rights, particularly if they are not too close to the realities of the problems, have simple replies to this question—almost as simple as those of the "centralists." These answers, however, have never been developed, administratively and fiscally, into any structure

which might be conceded a high probability of success. Every guardian of the democratic processes shares the desire to preserve the autonomy of the states. It is the translation of this autonomy into workable machinery which can meet the pressing issues of water resources development that confounds the objective student in this field.

The familiar device for dealing with many of these issues is to establish a federal authority. The beauty of this scheme depends upon the eyes of the beholder. The late Elwood J. Turner (1), formerly Chairman of the Interstate Commission of the Delaware River Basin, did not view too favorably the Tennessee Valley Authority type of organization, because he felt it tended to discourage local participation and rested too heavily upon the faith and credit of the national treasury. Morris L. Cooke (2), on the other hand, approvingly describes the same enterprise as an "Authority with a novel concept of local autonomy."

As to the apparent necessity of some form of regional agency, either for planning and integration or for the actual execution of projects, the committee is confronted with a long series of antagonistic proposals. Even within the U.S. Department of the Interior, two successive Secretaries have held opposing views on regional agencies.

Stevens and Horner (3) recently proposed, as substitutes for river valley authorities, the newly named "Basin Development Councils," whose main objective would be the development of basin plans on local and regional levels. They provide for only limited coordination and integration on the national level, however, except through the auspices of existing federal agencies.

Even aspirants for the presidential nomination enter the field of water resources development aware of the necessity for some form of regional cooperation. Within the past few months former Governor of Minnesota Harold E. Stassen (4) proposed in Omaha that a Missouri Valley regional organization be set up with authority for operating the numerous projects in the Missouri Valley, "as an integrated unit to assure efficiency and an adequate return to the taxpayers." The projects before this agency would have their origin in each participating state and the group would make contracts with a federal agency or agencies for management. Stassen conceives that this unit originating with the states is preferable to the proposals of Senator James E. Murray (D., Mont.), one of the active advocates of a Missouri Valley Authority, patterned after the familiar TVA.

All of this ferment stems from the fact that there are competitive interests involved in the development of water resources, that there are variable plans for development, that conflicting financial methods might be applied and that, in some very important areas, there is insufficient water to go around. Coupled with these difficulties, there are the great networks of interstate streams, representing in their watershed interests a very large part of the entire United States.

When to these complications are added the competitive interests and jealousies of individual states—and, at times, of parts of the same state—and of various federal agencies, the result is a situation of conflict which has been brewing for well over a century.

The issues are not likely to be resolved by name calling, even though one may detect, in a number of the associations pressing forward on the wa-

ter resources front, some interests that are less than frank and others that are more than selfish. These are the incidental and natural attributes of a national controversy in which easy answers are not discernible and in which the financial and socio-economic stakes are high.

Some anomalous conditions are created even by the participation of distinguished senators and members of the House of Representatives in certain powerful voluntary groups. It is one of the few instances in the determination of the national policy where members of Congress sit on both sides of the fence.

Faced with this mass of competing beliefs, desires and panaceas, the Committee on National Water Policy has determined that perhaps its most useful contribution to the Association would be to present certain general principles which might serve as a guide to the individual members. This way out is not chosen solely to avoid coming to grips with a national problem by considering only agreed principles discernible today, but also because these principles might later be translated into active policy as Congress pursues its deliberations.

There is a growing awareness among the states that the public interest requires the full and balanced utilization of water resources. The traditional practice of approaching flood control, pollution abatement, industrial and domestic water use, navigation, water power, irrigation, fisheries, and recreation as distinct and separate problems has led to wasteful expenditures. It has likewise stimulated conflict between agencies at various governmental levels, between governmental units themselves and between government and private groups.

A natural consequence of such frustrating dilemmas has been a less than adequate utilization and development of the nation's water resources.

Recent Indications

Some recognition of the necessity for a national water policy development, as well as for an agency to translate policy into program, appears in the recently proposed Senate Bill 2255 to establish a "National Water Policy Conservation Authority, and for other purposes." It was introduced in the Senate of the United States by Senator Patrick A. McCarran (D., Nev.) on March 3, 1948.

The agency proposed in S. 2255 is to study the problems of the conservation, development and utilization of water resources and the parallel problems of land conservation, development and utilization, in order to prepare recommendations to Congress on general policies.

The Association's committee has not reviewed S. 2255 in detail. The bill does not fulfill in all of its individual parts the views of the committee, but it does give recognition to the problems being discussed. Such an act, probably modified in certain important details—for example, the composition of the Authority itself—would revive once more on a federal level a reviewing agency to provide for the integration of interagency decisions and for an arena in which state-federal controversies might be resolved. In fact, the establishment of a forum of an official nature for state and federal discussion would restore a procedure employed many years ago and which, in modified form, existed only ten years ago.

It appears inescapable that some continuing group must be made available on the federal and state levels to

review and to integrate with expertness and objectivity the vast undertakings with which the country is confronted. Such a review cannot take place continuously on the battlefield without loss to the citizen, nor can it be accomplished by individuals or groups that have special interests, even though it should be emphasized that these deserve and must have their opportunities for hearing and adjudication. Integration likewise is impossible, on any comprehensive basis either locally or centrally, by competitive official groups whose primary concern must remain that of execution.

The principles herein proposed parallel in most essentials the attitude and philosophy of the Association's Board of Directors in its review of Senate Bill 418, dealing with the control of pollution in water resources. The views of the Board,* as discussed at its meetings in 1947 and 1948, may be generally paraphrased thus:

1. The Association has a continuing and vital interest in the reduction of the pollution of surface waters in the United States.

2. The Association holds that the primary responsibility for the control of stream pollution rests with the states, their political subdivisions and the industries therein located.

3. Recognizing that rivers do not respect state lines, the Association agrees that the coordination and promotion of stream pollution correction can be facilitated by limited legislation at the federal level.

4. The Association favors federal legislation in the field of stream pollution which will, to the greatest possible extent, use existing state and local authorities and facilities for the control of stream pollution.

5. The Association holds that, in the absence of state or local action, appropriate federal agencies should be empowered to direct pollution control works to be built and, if necessary, to provide loan funds for planning, as well as guidance in construction—if and when such works are ordered to be built.

6. When no state agency is empowered to enforce the reduction of stream pollution within a state and such pollution can be shown to affect interstate waters adversely, the Association agrees that a federal agency should be given authority to enforce correction of the conditions, to the end that the pollution of the nation's streams may be effectively controlled.

This resolution translates into general principles, covering a limited sector of the water resources problems, the views which might be approximately applied to the broader water resources development for the whole country.

The resolution recognizes strong joint interests, local and federal, but it attempts to preserve local autonomy. It places emphasis upon the obligation of the federal government to provide for stimulation, planning and integration. Some of the points emphasized apply equally well in the area of general resource development.

Since many of the enterprises, however, are of such large size and involve such great expenditures, special handling of the fiscal problems is required. These frequently transcend the possibilities of local financing.

* The resolution on pollution control adopted by the Board in January 1947 is quoted in the January 31, 1948, letter to all members, which accompanied the Secretary's report of the Board of Directors meeting held on January 20, 1948.

The point of view of the Association is further exemplified in its expressed attitude on the necessity of continuing the activities of the long established U.S. Geological Survey. This federal agency has rendered such invaluable service to communities of the nation in supplying factual data on surface and underground waters that reduction of its activities, as proposed by certain shortsighted individuals and groups, would be a real calamity to further water development. Efforts toward the curtailment of such necessary work are resisted by the Association, even though they may be masked under the blanket accusation of "interference with private enterprise."

The real issues of private versus public enterprise still remain to be battled out, but they, too, are not black and white. The committee has no hesitancy, however, in reminding the members of the Association that the history of public and private water supply development in this country provides many lessons, not the least of which is that there is room for both types of supply and that generalization, even in this comparatively limited area, has elements of danger.

Possible Areas of Agreement

[*Points 1–10 of this section have been accepted by the Board of Directors as an official statement of Association policy.—Ed.*]

Despite these ingredients of conflict, however, some general agreement now appears to be at hand on the major elements of a national water policy, although differences of opinion on implementation are likely to continue. Such a policy would:

1. Provide that first priority for water resources development be afforded to beneficial consumptive use, present or future, of waters for domestic and municipal purposes
2. Provide for the preparation of plans for the unified regulation and development of the river systems of the country upon sound engineering and economic principles
3. Provide for definite and effective programs for the construction of the projects included in such plans, the programs to be prosecuted as found desirable by Congress to meet current necessities
4. Provide that, when such programs may be flexibly deferred, they be made adjustable to the exigencies of unemployment relief in periods of business depression, and of defense in times of danger
5. Take proper account of economic, special and existing benefits in considering specific projects
6. Limit federal contributions toward projects to amounts warranted by all the national interests involved
7. Provide, in so far as practicable, for an equitable distribution of project costs
8. Assist in the settlement of controversies among states over interstate waters
9. Provide for systematic and effective cooperation among federal agencies—and between these and agencies or individuals in the several states—in formulating water plans and programs
10. Eliminate inconsistencies and conflicts in existing laws and regulations relating to the control or utilization of water resources.

If the elements of such a policy were developed on a federal level and machinery to implement it were provided, it would necessarily bring into function concurrently some kind of regional group with strong state representation. The exact nature and composition of these regional groups and their relationship to a newly created federal agency are not clearly delineated as yet. Such a regional group, however, will be of great significance, primarily because it would serve to furnish that local participation in federal, state and interstate decisions which, it is almost unanimously agreed, is a prerequisite for the future economical and logical development of the nation's resources.

The actual construction and administration of large works, so often on interstate streams, might be channeled to such regional organizations, to existing federal agencies, to individual states or subdivisions thereof, or to combinations of one or more of these. It is conceivable also that the "authority" type of operation, in whatever modified forms, would provide legal, administrative and fiscal machinery quite adaptable to regional necessities. At least it must be objectively weighed for such tasks in comparison with other available structures.

Resistance to any of the existing devices appears to rest primarily upon criticism of apparent or actual abuses in major detail. The heat generated in such criticism sometimes blinds both the advocates and the opponents to the residual assets of importance in the governmental structures themselves, whether local, state or regional. As in all human enterprises, the future of the water resources field is likely to show the value of compromise.

References

1. Turner, E. J. The Place of the States in the Field of Watershed Development. State Govt., **18**:2: (Feb. 1945).
2. Cooke, M. L. Plain Talk About a Missouri Valley Authority. Cong. Rec., June 10, 1947.
3. Stevens, J. C. & Horner, W. W. Proposed Substitute for River Valley Authorities. Civ. Eng., **15**:4:181 (April 1945).
4. New York *Times*, April 14, 1948.

Information Concerning Water Resources

An Official Statement of A.W.W.A. Policy

The official statement below is based on information developed by the Association's General Policy Committee in conference with representatives of the U.S. Geological Survey and a group of well drilling contractors. These conclusions, derived from the discussions by the committee, were submitted to the Board of Directors at the Atlantic City Conference meeting and were approved by the Board as a formal policy statement of the Association.

1. The American Water Works Association, speaking through its Board of Directors, holds the opinion that the body of information concerning the location and capacity of the nation's water resources is, at the present time, not adequate; and further holds the opinion that this information should be increased as fully and promptly as possible.

2. The Association approves the broad program of the collection of information concerning water resources implied in the basic act and subsequent authorizations by the Congress under which the U.S. Geological Survey operates.

3. The Association considers that the cooperative studies of ground water resources made by the U.S.G.S. and the various states are proper and of value to the public.

4. The Association further holds the opinion that cooperative agreements for the collection of water resources data between the U.S.G.S. and political subdivisions within states are in the public interest—provided that state water resources agencies in such instances either do not exist or are unable to provide the cooperative service required.

5. The Association holds the opinion that neither the U.S.G.S. nor the state agencies with which it cooperates should own or operate test well drilling equipment or equipment suitable for drilling water wells for later use. On the contrary, the Association holds the opinion that test well drilling should be done by competent private industry under contractual arrangements made by the driller with the U.S.G.S. or the state or local public agency concerned. In outlining these opinions in broad principle, the Association grants that when test well drilling needs to be done—and no private contractor is willing or able to do the work—the public agency may properly do it in order that the public interest be served effectively.

6. The Association, in holding these opinions, stands upon the underlying principle that the extension of federal or state activities into areas of action where private industry is competently prepared to serve the public need is undesirable and not in keeping with the nation's basic economic background.

7. The Association holds that it is the responsibility of the states, cities and private well owners and drillers to file with state agencies, as well as with the U.S.G.S., all well log data and production records which they possess, to the end that the nation's stock of information concerning water resources be as complete and as well documented as it is possible to make it.

Allocation of Colorado River Water

An Executive Committee Statement

The A.W.W.A. Board of Directors on May 7, 1948, referred to the Executive Committee for action certain representations concerning pending legislation in Congress which had to do with issues relating to the allocation of water from the Colorado River. The Executive Committee's statement follows:

To Whom It May Concern:

The American Water Works Association, an organization whose members are engaged in providing public water supply services in the Americas, is aware of the steadily increasing demand upon the water resources of the United States. The members of the Association hold the opinion that, lacking intelligent control at the highest levels of government, the future needs of all of the people for water cannot be met.

The Executive Committee of the Association's Board of Directors has had brought to its attention some of the issues relating to the allocation of the water flowing in the Colorado River. It is profoundly convinced that decisions concerning further development and uses of Colorado River water should be based upon the highest engineering, economic and social considerations, to the end that the people of the nation as a whole be served justly.

The Executive Committee further holds the opinion that the national interest requires firm and just decisions upon the matter and that these decisions should be reached with all promptness consistent with adequate engineering and economic review and understanding of the problem involved.

The Executive Committee therefore asserts, with full recognition of its responsibilities, the firm opinion that sound and just decisions concerning future developments of the Colorado River are vitally needed, and that any action which can be taken to reach such decisions should be given whatever impetus Congressional action will provide.

Harry E. Jordan
Secretary

Unanimously Approved June 4, 1948.
American Water Works Association
Executive Committee

L. H. Enslow
W. W. Brush — M. G. Mansfield
L. R. Howson — W. J. Orchard

Cathodic Protection of Steel Water Tanks

By Peter E. Pallo

A paper presented on May 5, 1948, at the Annual Conference, Atlantic City, N.J., by Peter E. Pallo, Asst. San. Engr., Hackensack Water Co., New Milford, N.J.

ALTHOUGH cathodic protection has become generally recognized in the water works industry as a method for protecting the submerged steel surfaces of water storage tanks against corrosion, there still exists much skepticism and confusion regarding the efficacy of this method.

A survey of existing installations shows that the water works operator has accepted two types of electrical devices for mitigating corrosion in steel tanks. One comprises the conventional cathodic protection installation, in which a direct current from an external source—impressed on either a suspended sacrificial or a nonsacrificial anode—flows through the corroding medium (water) and becomes superimposed upon the wall of the tank, where it stifles the flow of current accompanying the electrochemical corrosion process. The other type, also referred to as cathodic protection, requires no suspended anodes. In their stead, a system of electrical resistances is attached to the outside wall of the water storage tank, and a direct current applied from an external source flows through the resistances into the wall of the tank. In its progress report of 1946, the New England Water Works Assn. Committee on Cathodic Protection of Steel Tanks and Standpipes succinctly observes that this electrodeless installation is one about which "the Committee has as yet been able to find little information and less electrical theory to substantiate the claims of the manufacturer" (1).

Numerous conflicting reports of the protection secured with the electrodeless circuit; the confused impression that cathodic protection employing sacrificial anodes increases the dissolved oxygen content of the stored water; and the recent introduction of the galvanic magnesium anode as a method of corrosion prevention instigated the experimental studies presented in this paper.

Scope and Method

The investigation was designed to determine the degree of protection obtained in bare steel tanks provided with (1) an aluminum anode with an applied external potential, (2) a galvanic magnesium anode and (3) the electrodeless circuit with an applied external potential. A fourth tank, used as a control, was afforded no protection.

In order to ascertain the effect of cathodic protection on the dissolved oxygen content in the stored water, a stoneware crock was employed as a blank or control.

The study was conducted as rigidly and practically as possible. The interior walls of the experimental steel tanks were sandblasted clean, thereby increasing the surface activity of the

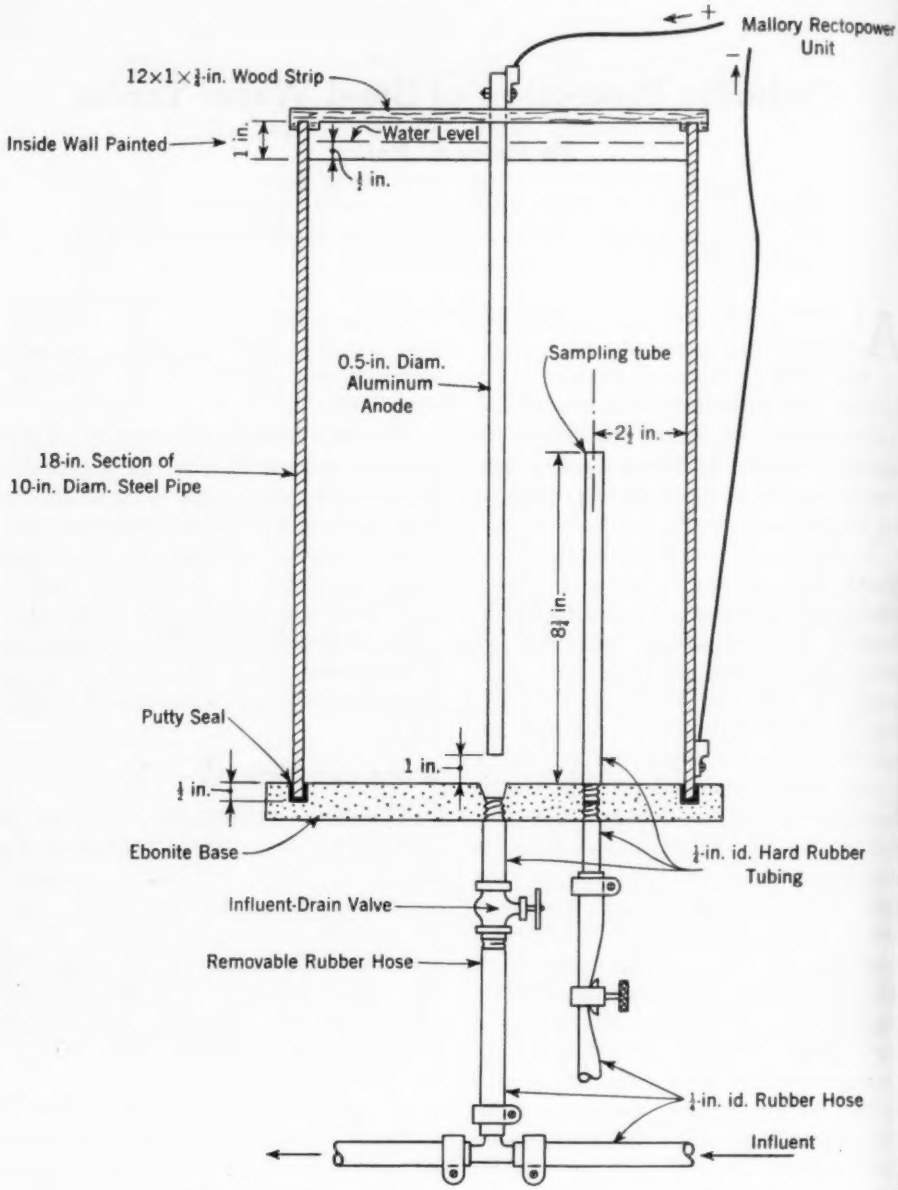

Fig. 1. Diagram of Experimental Tank Installation

exposed metal. By draining and filling the experimental units daily, the bare steel walls were subjected to the action of influent waters high in dissolved oxygen content. Corrosive activity was further enhanced during the 24-hour detention period by the increase in temperature of the stored water from the seasonally low influent temperature to room temperature.

Corrosion was measured in terms of actual weight loss of metal as well as by its recognized outward manifestations.

The experimental apparatus was installed at the purification plant of the Hackensack Water Co. at New Milford, N.J. The water used for the investigation was furnished from this purified, moderately aggressive surface supply, and was taken as it came, with all seasonal variations in temperature, dissolved oxygen and both chemical and mineral content. An average analysis of the experimental tank influent water for the duration of the investigation is shown in Table 1. This water had an average specific resistance, at 20°C., of 4,340 ohms per cubic centimeter.

Installation

Four 18-in. lengths of 10-in. diameter steel pipe were cut from a single length of pipe purchased in the open market. These lengths were sandblasted clean both inside and out, then painted on the outside with two coats of aluminum for protection against atmospheric corrosion. After being carefully weighed to the nearest ounce, the tanks were set in an ebonite base and sealed in with Dupont PX putty. A stoneware crock, 20 in. deep and 10½ in. in diameter, completed the tank installation. Each of the five units was provided with a common drain and influent connection, as well as a sampling tube which extended half way up into the tank at a distance of half the radius from the tank wall.

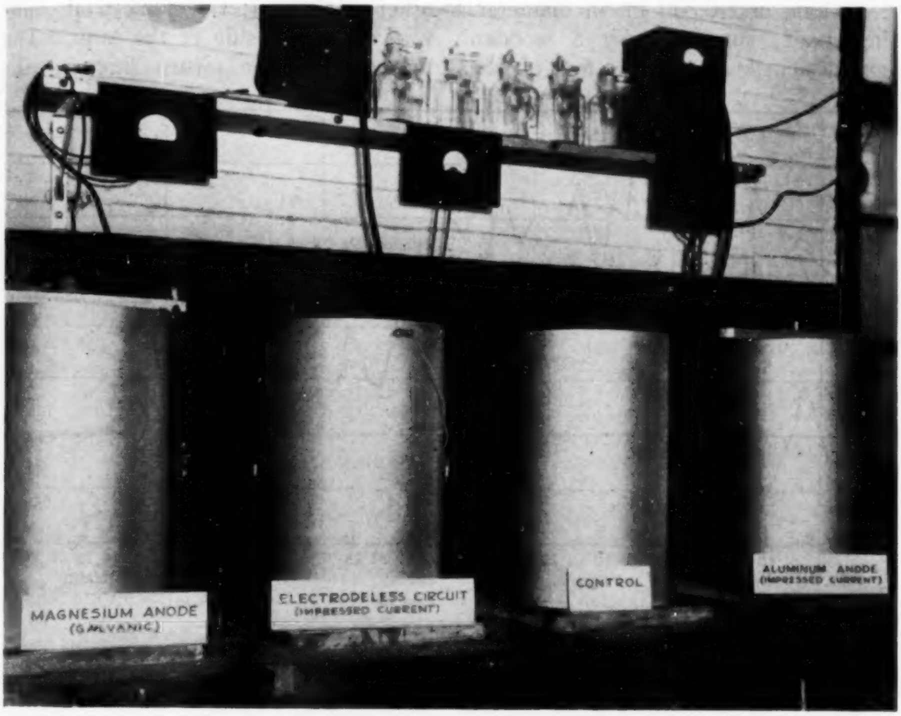

FIG. 2. Complete Experimental Tank Installation

All connections other than the influent-drain valve were of nonmetallic material, hard rubber tubing and rubber hose being used. The installation details of one of the steel experimental tanks (aluminum anode) is shown in Fig. 1.

Protection Applied

Tank No. 1 was equipped with a Dow Chemical Co. magnesium anode, 18 in. long and 0.840 in. in diameter. The anode, supported by a wooden strip attached across the top of the tank, was centered along the axis of the tank and terminated 1 in. above the bottom of the ebonite base. The anode and tank wall were electrically connected through a double-throw switch to facilitate milliammeter readings and to exclude ammeter resistance from the electrical circuit.

The current density at the start of the investigation was calculated to be 4.2 ma. per square foot or 1 amp. per 240 square feet of metal surface. As the formation of a protective wall coating progressed, the current was found to decrease proportionately. At the termination of the experiment, the current density was found to be 0.7 ma. per square foot or 1 amp. per 1,480 square feet.

Tank No. 2 was furnished with the electrodeless circuit type of installation. A Mallory Rectopower unit delivered 30 ma. at 8 v. to two sets of two 1,000-ohm wire-wound resistors in parallel, which were connected opposite to each other on the exterior tank wall, midway down the side of the tank. The two negative or return lines to the rectifier were connected to the exterior tank wall at a 90-deg. angle to the resistor connections, one at the top and the other at the bottom of the tank. The current applied to the tank shell was calculated to be 8.1 ma. per square foot or 1 amp. per 125 square feet of metal surface.

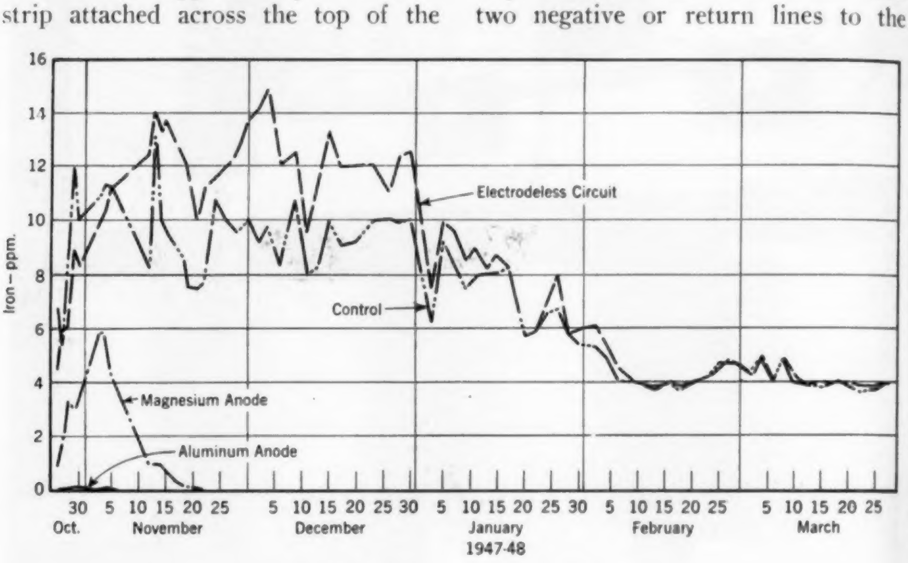

Fig. 3. Iron Pickup in Tank Effluent

Tank No. 3, employed as the control, was afforded no protection and was allowed to corrode freely.

Tank No. 4 (Fig. 1) was supplied with an Alcoa 17ST4 aluminum anode, 18 in. long and 0.50 in. in diameter,

TABLE 1

Influent Water Analysis

Item	Quantity *ppm.*
pH	7.3
Color	8
Turbidity	0
Free CO_2	5
Alkalinity* ($CaCO_3$)	51
Soap hardness ($CaCO_3$)	79
Total iron	0.03
Total solids	150
Magnesium	5.5
Calcium	27.9
Sulfates	36.0
Chlorides	10.3
Silica	6.3
Dissolved oxygen	11.2

* Methyl orange.

months of the investigation. Milliammeter and voltmeter readings were taken before draining and after refilling. Samples of the influent and effluent waters of the four tanks were collected for analysis on an average of three times weekly. The determinations made on each of the five samples collected included temperature, pH, turbidity, color, alkalinity, dissolved oxygen and total iron pickup. For the stoneware crock, the temperature and dissolved oxygen content of both the influent and effluent waters were the only determinations made.

After every draining operation, the bottom of each tank was flushed free of settled deposits before refilling, care being exercised not to disturb any coating or deposit on the tank walls.

TABLE 2

Iron Pickup in Effluent

Tank No.	Type of Protection	Iron Pickup—*ppm.*		
		Maximum	Minimum	Average
1	Magnesium anode (galvanic)	5.97	0	0.46
2	Electrodeless circuit	14.87	3.65	8.14
3	Control	13.27	3.60	7.10
4	Aluminum anode (impressed current)	0.11	0	0.02

supported, centered and terminated from the ebonite base as in the magnesium anode installation. The current was obtained from a Mallory Rectopower unit, delivering 20 ma. at 8 v. The positive lead of the rectifier was securely fastened to the aluminum anode, and the return or negative lead was made fast at the bottom of the exterior tank wall. The current density applied to the tank shell was calculated to be 5.4 ma. per square foot or 1 amp. per 185 square feet of metal surface.

Figure 2 shows the actual, complete experimental installation.

Procedure

The tanks were operated on a daily fill-and-draw cycle during the 5½ months of the investigation. Milliammeter and voltmeter readings were taken before draining and after refilling.

Upon completion of the experimental studies, the steel tanks were removed from the system and were cleaned and weighed to the nearest ounce to determine the total loss of iron.

Results

In presenting the results of the experimental work, it must be pointed out that, because of the selected location of the sampling tubes, the analyses of the tank effluent samples represent an average condition existing in the tank at the time when the sampling was made.

Iron Pickup

Determinations of the amount of iron pickup (Fig. 3), indicating the rate of active corrosion, show that the maximum iron concentrations were found in the effluents of both the electrodeless circuit and the control tanks, the former exhibiting generally higher iron values. It is apparent that both tanks conformed to the behavior that may be expected of freely corroding surfaces.

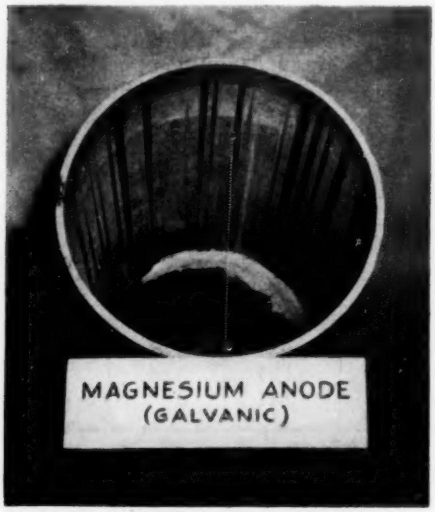

FIG. 4. Interior of Tank No. 1

The high iron concentrations observed in the effluent of the tank protected by galvanic magnesium implied that an aggressive corrosion attack occurred during the first four weeks of the investigation. Following this period adequate protection was demonstrated by the occasional slight increases in the iron pickup concentrations which were well within the range of experimental error.

The effluent of the tank provided with the aluminum anode (impressed current) showed a slight iron pickup during the first week of service and only incidental minor increases thereafter. These results also indicate effective corrosion prevention.

The maximum, minimum and average iron pickup values for the duration of the investigation are given in Table 2.

Loss in Weight of Metal

The loss in weight of metal from the four tanks was found to conform to the order in which the higher iron

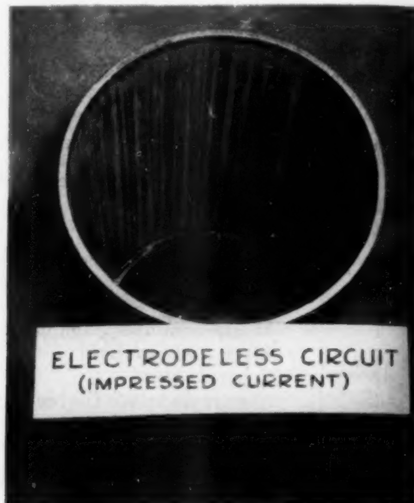

FIG. 5. Interior of Tank No. 2

concentrations were observed in the effluents of the experimental tanks; that is, the greater the iron concentration increase in the effluent, the greater the loss in weight of metal. These losses are shown in Table 3.

Surface Conditions

The corrosion product adhering to the walls of both the electrodeless circuit tank and the control was found to be a granular, loosely adherent iron oxide which is low in resistance to the diffusion of oxygen (2). The corrosion assumed a distinct vertical pattern

attributed to the method of manufacture of the pipe. The only difference observed on the walls of the two tanks was a marked pitted appearance in the electrodeless circuit tank which was not evident in the control. This pitting was not characteristic of the customary cavity found under tubercles, but rather gave the impression that a bursting action had occurred at numerous points in the oxide coating.

Figures 4 and 5 show the condition of the tank walls prior to the final cleaning operation. The corrosion products were easily removed from both tanks and, as was to be expected, the cleaned surfaces exhibited a conspicuously grooved appearance.

In passing, it is of interest to mention that the bursting action previously described was also noted on the walls of a 125,000-gal. elevated wash water storage tank. This structure, located at the New Milford Plant of the Hackensack Water Co., was equipped with the electrodeless circuit (in the form of the Rusta Restor Element Anode). The current density applied was 1 amp. per 3,000 square feet. A report made on the tank interior referred to the "pock-marked appearance of the red-lead covering, suggestive of perforated paint blisters" (3). Thirty-one months of observation and field experimentation within the tank led to the conclusion that the Element Anode afforded no protection against corrosion.

The wall of the tank protected with the galvanic magnesium anode (Fig. 6) was covered with a fine, buff-colored, tightly adherent deposit. A qualitative spectrographic analysis of a sample of this coating showed that it contained magnesium, calcium, sodium, aluminum, silica, iron and slight traces of copper and manganese. Vertical rust streaks formed during the first month, in which active corrosion occurred, were found to be effectively sealed and no appreciable attack was noticed on the wall of the tank after cleaning. The investigation also showed that the magnesium anode exerted a chemical conditioning effect on

FIG. 6. Interior of Tank No. 3

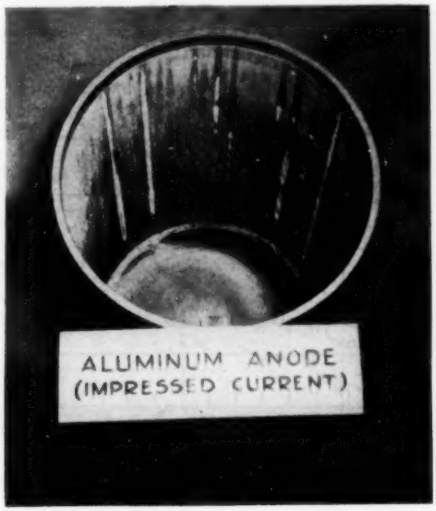

FIG. 7. Interior of Tank No. 4

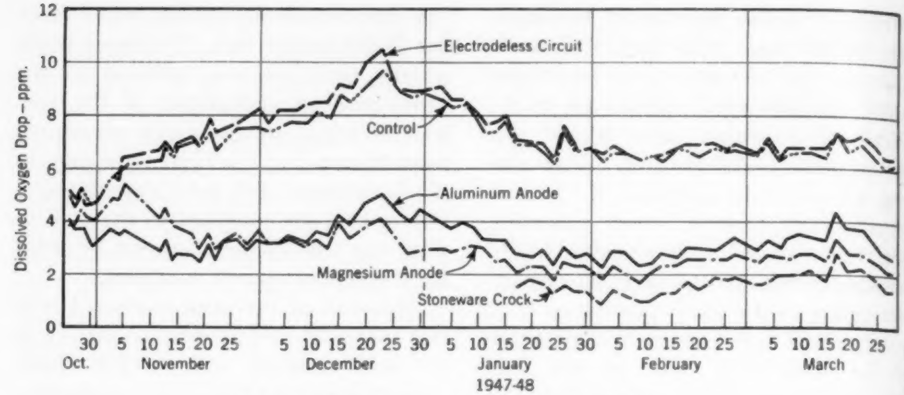

Fig. 8. Dissolved Oxygen Drop in Effluent

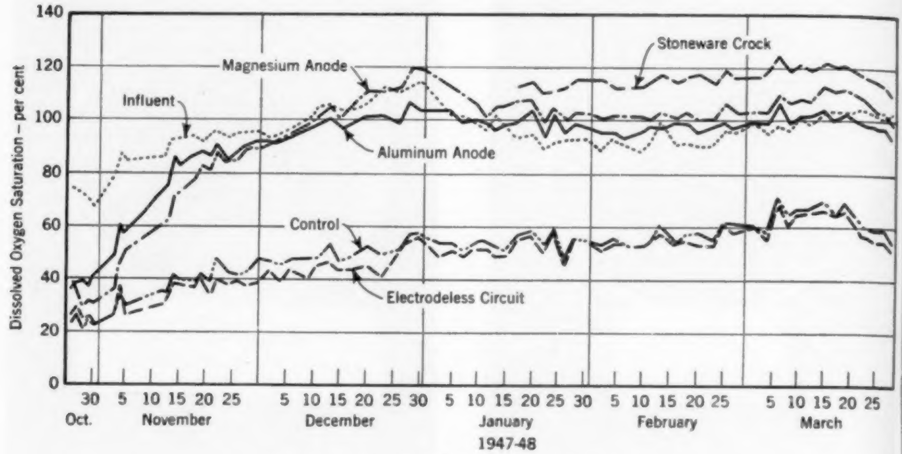

Fig. 9. Dissolved Oxygen Saturation

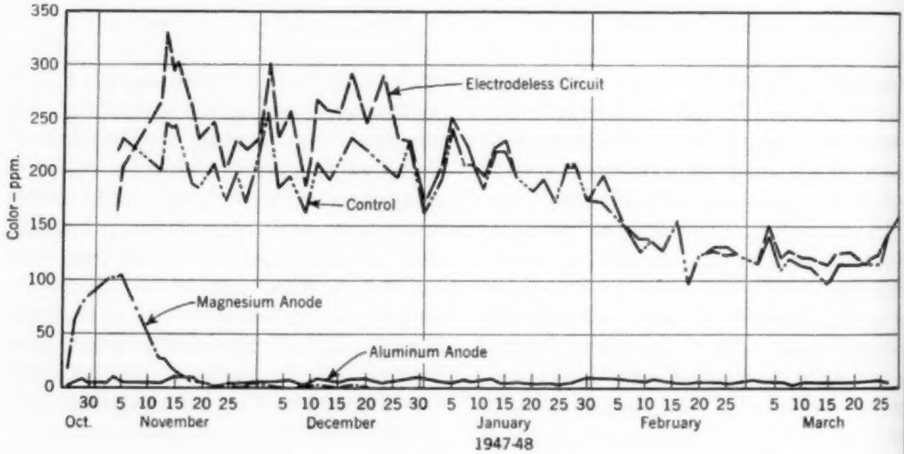

Fig. 10. Color Increase in Effluent

the stored water to render it less aggressive, as evidenced by a substantial increase in the pH and alkalinity of the tank effluent. These results with cold water conform to those reported in actual practice when the galvanic magnesium anode is used to control the corrosion of hot water storage tanks (4). Although the galvanic magnesium anode has inherent limitations, it has been demonstrated that it can be successfully used for inhibiting corrosion. Field experimental applications have been installed in the risers of elevated water storage tanks (5) and in deep well turbine pumps (6).

The tank protected with the aluminum anode (impressed current) displayed a slight tendency to corrode during the first week of the investigation. Within the third week a recognizable whitish gray film began to form on the tank wall. The points of initial corrosion attack became coated with increasingly heavier white deposits as the investigation proceeded. This is clearly shown in Fig. 7. Sudrabin (7) explains the formation of the heavy white deposits as resulting from the application of a current in excess of the minimum protective current density required.

A qualitative spectrographic analysis of a sample of the wall coating showed it to contain calcium, magnesium, sodium, aluminum, silica, iron and a trace of manganese. After the removal of the coating, the tank wall presented the appearance of a well-preserved, clean gray steel.

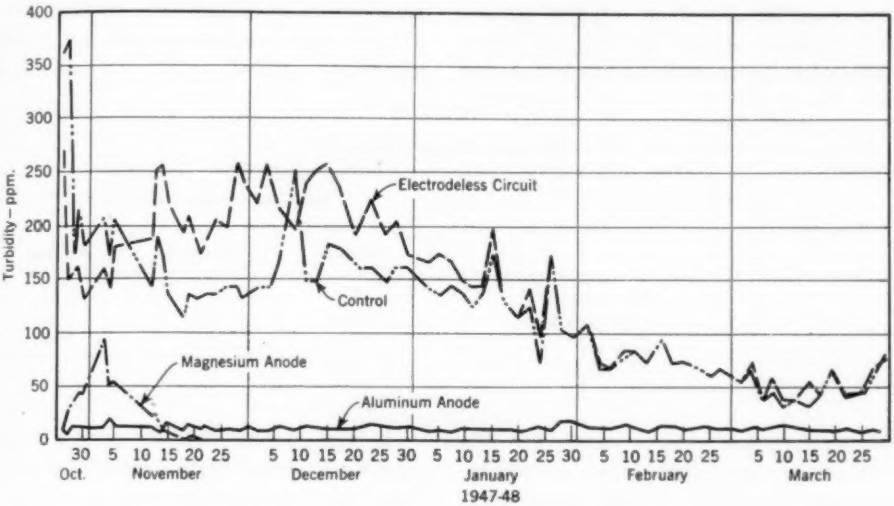

FIG. 11. Turbidity Increase in Effluent

Oxygen Depletion

Greater dissolved oxygen depletion values (Fig. 8) were found in the effluents of the two tanks—No. 2 and 3 —which were shown to be corroding freely. Maximum, minimum and average dissolved oxygen depletion values are shown in Table 4.

The natural loss of dissolved oxygen observed in the effluent of the stoneware crock (Fig. 8) was less than that found in the effluents of the cathodically protected tanks. These results emphasize the fact that the dissolved

TABLE 3

Loss in Weight of Metal

Tank No.	Type of Protection	Weight Loss *oz.*	Weight Loss *per cent*
1	Mg anode	5	0.67
2	Electrodeless	17	2.27
3	Control	15	1.99
4	Al anode	3	0.40

oxygen content of the water is not increased when sacrificial anodes of the galvanic type such as magnesium or aluminum with an applied external potential are used. It is important to note that the dissolved oxygen saturation values, shown in Fig. 9, were higher for the stoneware crock than for the steel tanks. Were it not for this fact, erroneous deductions about increased dissolved oxygen concentrations could easily be made.

Color and Turbidity Increase

The water works operator readily understands and appreciates only too well the outward manifestations of corrosion, such as the increase in color and turbidity (*see* Fig. 10 and 11). The increase noted in the color and turbidity of the effluent from the tank protected with the aluminum anode (impressed current) was of small magnitude compared to the freely corroding tanks and is attributed to the coagulating effect caused by the dissolution of the aluminum anode (8).

TABLE 4

Dissolved Oxygen Depletion

Tank No.	Type of Protection	Dissolved Oxygen Drop—*ppm.*		
		Maximum	Minimum	Average
1	Mg anode	5.4	1.7	3.0
2	Electrodeless	10.5	4.5	7.2
3	Control	9.7	4.6	7.0
4	Al anode	5.0	2.3	3.2

Conclusions

The results secured during this investigation demonstrate cathodic protection to be a practical method of protecting the submerged steel surfaces of water storage tanks.

1. The use of a properly installed sacrificial aluminum anode provided with an external potential was found to prevent adequately the corrosion of a bare steel surface.

2. The use of a properly installed sacrificial galvanic magnesium anode was found to inhibit the corrosion of a bare steel surface despite an initial aggressive attack.

3. The electrodeless circuit, frequently referred to as cathodic protection, showed no protection against corrosion. This conclusion is in agreement with that reached after 31 months of an actual field investigation.

4. The dissolved oxygen concentrations in the stored water were not found to increase when sacrificial anodes, either of the galvanic type, such as magnesium, or aluminum with an applied external potential, were used.

Acknowledgments

The author gratefully acknowledges the constructive interest professed by the management of the Hackensack Water Co., Weehawken, N.J., which provided the equipment, space and wa-

ter for the investigation, as well as the facilities of its analytical laboratory.

The author is indebted to Rolf Eliassen, Prof. of San. Eng., New York University, New York City; F. J. LeFebvre, Electro Rust-Proofing Corp., Belleville, N.J.; P. S. Wilson, Gregg Co., Philadelphia; H. A. Robinson, Dow Chemical Co., Midland, Mich.; and R. C. Bromelmeier, Aluminum Co. of America, Edgewater, N.J., who so generously contributed their time and suggestions.

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Erratum

The outbreak of gastro-enteritis which was listed in "Analysis of Water-borne Outbreaks" by Rolf Eliassen and Robert H. Cummings (May 1948 JOURNAL, Vol. 40, p. 521) as having occurred in Seattle in 1943, actually took place beyond the limits of that city, nor was the municipal water system involved in any way.

Future Trends in Water Rates

By Albert P. Learned

A paper presented on March 11, 1948, at the Kansas Section Meeting, Wichita, Kan., by Albert P. Learned, Asst. Engr., Black and Veatch, Cons. Engrs., Kansas City, Mo.

THE present operating costs of water utilities are the highest ever experienced in this country, with the result that the spread between water revenues and operating expenses is becoming increasingly narrow. Where fixed charges have exceeded this spread, it has been necessary to raise the rates or subsidize the municipally owned plants by funds from other sources.

Management does not initiate rate increases except as a last resort, and if the utility can weather a temporary shortage of current revenue by the use of an accumulated reserve, the tendency is to avoid an increase in rates. If present conditions persist, however, or a substantial portion of the rise in costs remains in effect, increases in water rates will be imperative for many utilities. This paper will outline briefly the conditions that influence rates and will attempt to indicate future trends.

Labor and Material Costs

The two major elements affecting prices at the present time are materials and labor. Both of these factors are reflected in construction, operation and maintenance costs. Table 1 shows the cost of labor, materials and equipment in various years from 1913 to 1948, expressed as a percentage of the late 1947 or early 1948 costs. The labor figures are based on union rates in a large middle-western city but indicate the approximate relationship of both union and nonunion labor during the period.

Table 2 gives the percentage increase in material prices between 1939 and 1948.

The history of prices from 1913 to 1948 shows clearly that the general trend has been upward; even in 1932, at the lowest ebb of the depression, certain costs were equal to or greater than those in 1921, the previous high-point. The indications are that prices will neither decline to prewar levels nor remain at present peaks. After the current demand has eased off so that the buyer has an opportunity to make a selection and the seller is required to meet competition, it is probable that prices may decline from 10 to 20 per cent, with a resulting price level 40–60 per cent higher than before the war.

Capital Charges

The necessity for an increase in rates will vary with different companies. A static company, for instance, will not need an additional return, while one that has had to invest a considerable amount of new capital in the high-price period will feel the effect of added fixed costs, including both interest on debt and added depreciation charges. A growing company which has been using its depreciation reserve for extension capital will find it has insuffi-

cient funds for this purpose if its program continues at the same rate of increase in units of physical property, because the cost of such units has materially increased.

Many municipal corporations do not attempt to collect interest on their property, and, unfortunately, some utilities do not try to include depreciation provisions in their rate structure. None of these utilities, however, can escape the costs of new construction if they are adding extensions. A utility that has made a practice of spending a relatively uniform amount each year for extensions is finding that this sum has been producing a smaller number of property units in recent years.

It has been suggested that depreciation rates be increased to provide such funds, but this introduces the question of why an increase in depreciation reserve rates is needed when the current rate is sufficient to provide for the cost of the present property by the time the debt is retired. If it is necessary that the depreciation rate be increased to keep the water utility intact, and at the same time provide for normal extensions which comprise a small percentage of the total plant, the purpose of the increase should be properly identified. Current financing of normal extensions ordinarily produces a lower over-all cost than the use of long-term bonds.

TABLE 1

Labor and Material Costs, 1913–48

Item	Cost (1947–48 = 100)				
	1913–15	1921	1932	1939	1945
Labor					
Carpenter	27	67	55	68	83
Electrical Worker	35	58	70	79	86
Common Labor	27	48	55	68	80
Plumber	35	44	64	79	86
Steamfitter	35	44	64	79	86
Materials and Equipment					
Boilers	25	53	49	76	82
Cast-Iron Pipe	27	67	38	54	56
Copper	75	59	26	51	55
Hydrants and Valves				63	
Motors	47	94	62	69	69
Pumps	32	56	59	70	77
Lead	29	31	21	33	38
Piping	36	68	67	72	80
Steel Pipe (small, black)	40	73	77	69	69
Steel Pipe (small, galvanized)	40	72	75	64	69
*E. N.-R. Index**	21	46	36	54	71

* *Engineering News-Record* Construction Cost Index.

The original cost of a utility actually is the sum of its reproduction cost through the years, or its historical reproduction cost. The addition of current extensions will not add materially to this measure of a rate base unless the additions comprise a substantial part of the entire plant. Consequently, a rate based on original cost is a gradually changing structure and only slowly reflects the increased cost of construction.

The ratepayer ordinarily objects to providing, through payments to depreciation reserves, any amount more than enough to cover the cost of the present unit upon retirement. Although unwilling to contribute to the reserve needed to meet added capital expenditures for replacement, the rate payer cannot object to providing adequate funds for a higher-priced unit of property when that unit becomes a part of the plant serving him.

Operating Expenditures

Increased capital costs have usually not been the principal factor in rate increases. The immediate causes have

TABLE 2

Increase in Material Prices Between 1939 and 1948

Item	Increase *per cent*
Cast-Iron Pipe	87
Steel Pipe	
Black	44
Galvanized	57
Copper	100
Lead	200
Hydrants and Valves	60

been primarily the enlarged operating and maintenance expenses.

A study of three properties, or groups of properties, in different sections of the United States showed that the operating ratio (expenses expressed as a percentage of total revenue) has increased approximately 10 per cent between 1939 and 1946; namely, from 50 to 55 per cent. In this same period, maintenance has risen from 4.3 to 5.7 per cent of operating expense—an increase of 33 per cent—while depreciation has increased from 7.5 to 8 per cent of the operating expense. The gross income was approximately 10 to 12.5 per cent of the property and plant in 1946. Income taxes on these properties have doubled in amount since 1939, but other taxes have shown little change.

Many water utilities have been saved a great deal of the increased pumping costs because of a very good electric pumping rate, which has not reflected all the added expense the water utility would have undergone if it had been producing its own energy. Freight rates, however, have increased approximately 40 per cent since 1939 and these certainly enter into the water utility's cost considerations.

Conclusion

The foregoing facts concerning operating expenses and material costs can lead to but one general conclusion: the future trend of water rates is upward.

The water works industry cannot hope for loads that may reduce the effect of rising costs. The increased load on a water works system is usually a peak load, such as for sprinkling or air conditioning, which is superimposed on the normal peak load or occurs at a time when either water is scarce or added investment is required to supply the seasonal demands. It is imperative that rate increases be equitable in their application, and that seasonal loads bear their fair share of the costs.

In conclusion, attention is directed once more to Table 1, which shows the extent of the rise in prices since 1913. Many water utilities maintain rates that are practically the same as in 1913, or in periods prior to 1932. It takes no stretch of the imagination, therefore, to suggest a change in the rate structure. The signs all indicate that an upward revision of 10–35 per cent in water rates is warranted.

Studies of Properties of Sulfur Jointing Compounds

By W. W. Duecker, James W. Estep, M. Glenn Mayberry and J. W. Schwab

A paper presented on May 5, 1948, at the Annual Conference, Atlantic City, N.J., by W. W. Duecker, Texas Gulf Sulphur Co., New York City; James W. Estep and M. Glenn Mayberry, Fellows, Mellon Inst. of Industrial Research, Pittsburgh, Pa.; and J. W. Schwab, Texas Gulf Sulphur Co., Newgulf, Tex.

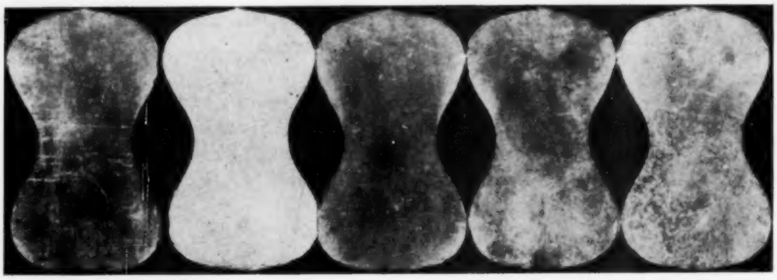
DURING the past fifteen years considerable information has been collected on the properties and uses of sulfur cements. It has been demonstrated that the quality of sulfur cements—that is, their tensile and crushing strength—is determined in part by the proportion of sulfur and the kind and grading of aggregate used in their manufacture (1). It has been shown that the plasticity and the resistance of sulfur cements to thermal shock can be modified by adding a plasticizer (1). Provisional methods for testing sulfur cements have been proposed (2) so that users can carefully appraise these products. The resistance of such cements to acids, alkalies, oils and the like has been determined, to guide users of these jointing compounds (3). And, more recently, West (4) has published a detailed review of the literature describing the effect of sulfur on various metals that enables users to tell where and where not to use sulfur jointing materials. It is thus evident that there exists a substantial body of basic literature on these compounds which should be of aid in their intelligent production, testing and application.

Few published data, however, are available about the life of sulfur cements employed as jointing materials for cast-iron bell-and-spigot water mains. Large quantities of these cements are used for this purpose, however, and it has been reported by Beckwith and Bovard (5) that cements so used are subject to attack and deterioration by sulfur bacteria. It was therefore decided to obtain data on the life of such cements and, if they were found to be subject to bacterial action, to determine whether that effect could be controlled.

Preparation of Specimens

A series of sulfur cements containing various bactericides was prepared and cast in the form of figure-eight briquets according to the procedure outlined by McKinney (2). The cements, whose composition is given in Table 1, contained approximately 55 per cent by weight of sulfur and 45 per cent of the graded silica aggregate described in Table 2. Prior to adding the aggregate, various bactericides in the proportion of 0.1 and 1.0 per cent, based on the weight of the sulfur, were uniformly dispersed in the sulfur at

130°–140°C. Most of the liquid bactericides dissolved in the sulfur. The solid compounds were ground to 250-mesh fineness before dispersion. The weight and density of the cements were determined by methods described by McKinney (2). Each briquet was banded with a thin strip of lead carrying an identifying number. From 76 to 115 briquets of each of the various cements were prepared. Twelve of each kind were kept in the laboratory;



Arsenous Oxide 0.1% | Cresol-c 1.0% | β-naphthol 1.0% | Selenium 1.0% | Xylenol 1.0%

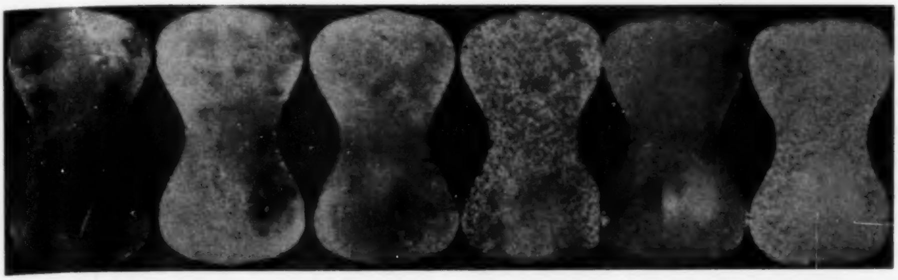
Fig. 1. Original Appearance of Briquets (Group 1)

TABLE 1

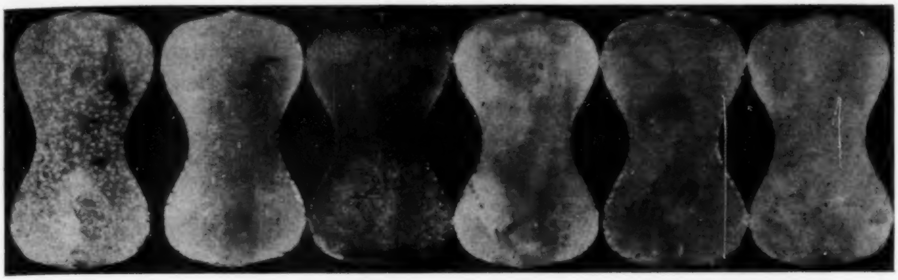
Composition of Sulfur Cements

Sample No.	Type of Bactericide	Sulfur	Aggregate	Bactericide*
		per cent		
380	Arsenous oxide	55.47	44.48	0.1
387	Arsenous oxide	60.8	38.6	1.0
0	Control	55.0	45.0	
03	Copper sulfate	54.9	44.9	0.1
30	Copper sulfate	54.3	44.4	1.0
73	Cresol-c	54.9	45.0	0.1
37	Cresol-c	54.7	44.8	1.0
78	*o*-cyclohexylphenol	54.9	45.0	0.1
87	*o*-cyclohexylphenol	54.7	44.8	1.0
38	*o*-hydroxydiphenyl	54.9	45.0	0.1
83	*o*-hydroxydiphenyl	54.7	44.8	1.0
8	Lead sulfide	54.9	45.0	0.1
08	Lead sulfide	54.7	44.8	1.0
77	Mercuric oxide	54.9	45.0	0.1
7	Mercuric oxide	54.7	44.8	1.0
88	Naphthalene	54.95	45.0	0.1
308	Naphthalene	54.7	44.8	1.0
370	β-naphthol	54.9	45.0	0.1
378	β-naphthol	54.7	44.8	1.0
00	Thiokol	70.26	19.94	9.8
33	Selenium	54.9	45.0	0.1
3	Selenium	54.7	44.8	1.0
07	Xylenol	54.9	45.0	0.1
70	Xylenol	54.7	44.8	1.0

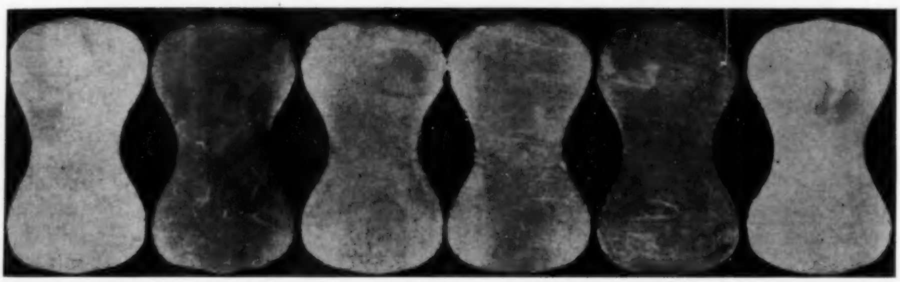
*Based on weight of sulfur.



Arsenous Oxide 1.0% | Copper Sulfate 0.1% | Cresol-c 0.1% | o-cyclohexyl-phenol 1.0% | o-cyclohexyl-phenol 0.1% | o-hydroxy-diphenyl 0.1%



o-hydroxy-diphenyl 1.0% | Lead Sulfide 0.1% | Lead Sulfide 1.0% | Mercuric Oxide 0.1% | Mercuric Oxide 1.0% | Naphthalene 0.1%



Naphthalene 1.0% | β-naphthol 0.1% | Thiokol 9.8% | Selenium 0.1% | Xylenol 0.1 | Control

Fig. 2. Original Appearance of Briquets (Group 2)

one-half of the remainder was buried in Texas and the rest in Pittsburgh. Prior to burial, however, representative samples were selected from each lot and their tensile strength determined according to methods described by McKinney (2). The initial appearance of these briquets is shown in Fig. 1 and 2.

Test Areas

All briquets were buried at a shallow depth to insure the presence of ample oxygen for the growth of bacteria. One set was buried behind the old Mellon Institute building on O'Hara Street, Pittsburgh, Pa., at a depth of 18 in. and covered with the

existing clay soil. The site, which was at the base of a slight rise, was well moistened by rain and drainage water. It was anticipated that this site would duplicate many of the conditions found in the north temperate zone and that the results obtained could be applied to what might be called normal conditions.

A duplicate set of the briquets was buried at a depth of 6 in. on the site of

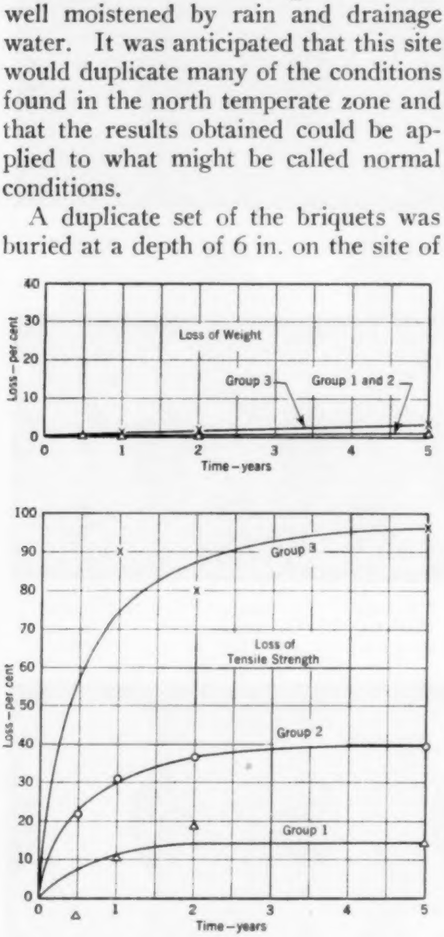


Fig. 3. Loss of Weight and Tensile Strength (Normal Exposure)

vat No. 19 in Newgulf, Tex. This in no way represents a normal site, for the area had formerly been used for storing sulfur. In the course of years, the moist, black soil had become well contaminated with sulfur-oxidizing bacteria (6), evidently because optimal conditions existed for their growth. The soil had a pH of 3 and was sufficiently acid to discolor wood and rust iron at a rapid rate. Extreme bacteriological conditions were encountered in this site, and it is questionable whether similar conditions would be duplicated in any area where sulfur cements are normally used.

Appraisal of Specimens

At periodic intervals a number of briquets of each series were recovered from the test areas and returned to the laboratory. The briquets were carefully washed to remove extraneous matter, dried with a towel and allowed to stand in the laboratory to come to equilibrium. The weight, density and tensile strength of each briquet were then determined.

TABLE 2

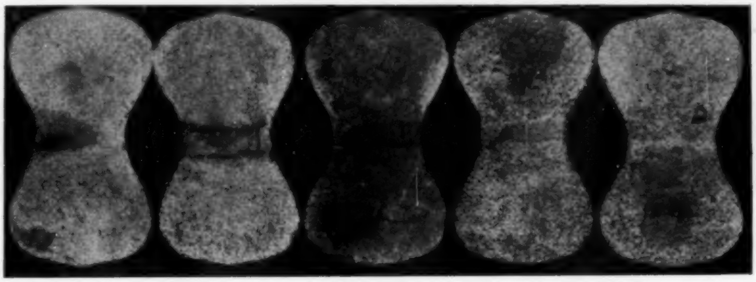
Screen Analysis of Aggregate

Standard Screen Mesh Through	On	Per Cent by Weight
	20	0
20	28	1.6
28	35	14.7
35	48	40.0
48	65	23.7
65	100	11.8
100	150	4.3
150	200	2.8
200		1.1

Originally it was planned to follow the aging of the various briquets by studying the changing physical properties, such as tensile strength, density and alteration in weight. It was hoped that it might be possible to discover a correlation between the loss in weight and the change in tensile strength. It was anticipated that the effect of bacterial action might be expressed in inches of penetration per year. But, after the first briquets had been returned to the laboratory, it became apparent that no such correlation could be established. The penetration per year could not be determined because

the surface of the briquet was nonhomogeneous, consisting of fine particles of silica imbedded in sulfur. It was also impossible to correlate the change in weight with the change in tensile strength. Initially the briquets weighed about 150 g. with a maximal variation of 5 g. between briquets. They had a tensile strength of about 500 psi., with a variation of approximately 10 per cent in a given series. After aging and exposure, however, the variation in a given series was greater because of the uneven effects of weathering and bacterial action. It then became clear that it was impossible to establish an exact mathematical correlation. This difficulty of correlating corrosion data and of appraising materials of construction has been encountered by others. Speller (7) has described the problems in assessing corrosion resistance and comes to the conclusion that the best way of testing a given material is to build it into equipment and test it to destruction.

Since there seem to be no standards for determining corrosion resistance, and since it was difficult to obtain an exact mathematical correlation of the data collected, an arbitrary method of appraising the sulfur cements was adopted. The weight, density and strength of each of the briquets brought to the laboratory were carefully determined. The average weight, density and strength of a given lot were then calculated. The briquets were next carefully inspected for pitting, crazing and spalling. A careful appraisal of the weight and tensile strength data, coupled with visual inspection of the various briquets, made it possible to place the cements in one of three groups: group 1, superior to the control; group 2, equal to the control; and group 3, inferior to the control.



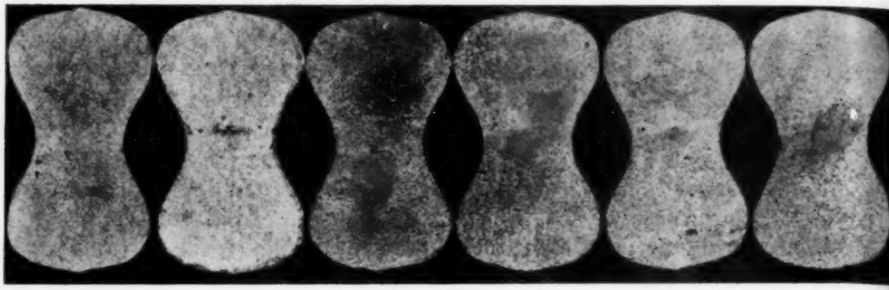
Arsenous Oxide	Cresol-c	β-naphthol	Selenium	Xylenol
0.1%	1.0%	1.0%	1.0%	1.0%

FIG. 4. Group 1 After Five Years' Normal Exposure

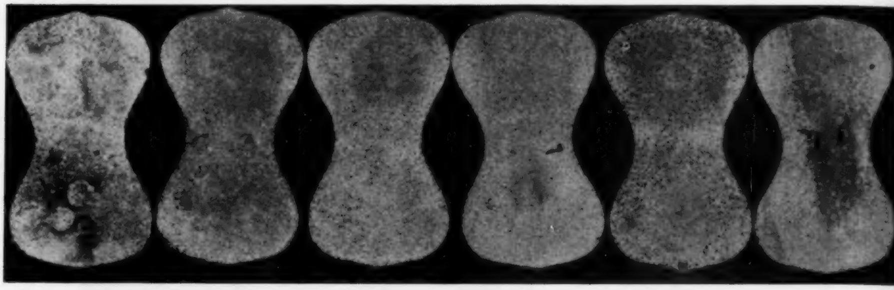
Normal Aging of Cements

All the data regarding the aging of the sulfur cements buried in Pittsburgh under what are termed normal conditions have been assembled in Tables 3 and 4 and plotted in Fig. 3. According to these data, during the five years' exposure the cements show a maximal variation in weight ranging from + 0.6 to − 3.6 per cent. As sulfur cements normally absorb about 1 per cent of moisture, it is believed that the change in weight is of little significance.

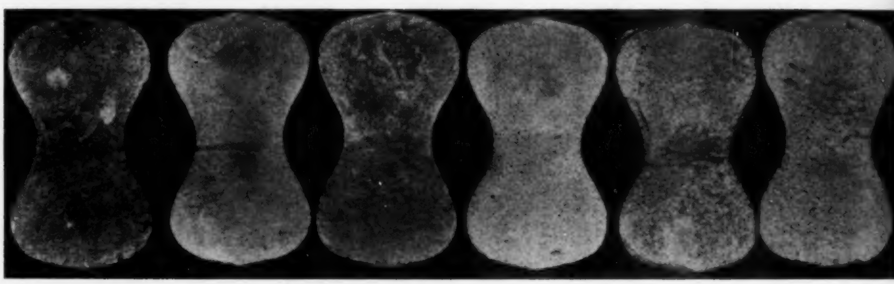
Examination of the tensile strength data, however, reveals that practically all the cements have undergone change. Group 1 at the end of five years had



Arsenous Oxide	Copper Sulfate	Cresol-c	*o*-cyclohexyl-phenol	*o*-cyclohexyl-phenol	*o*-hydroxy-diphenyl
1.0%	0.1%	0.1%	1.0%	0.1%	0.1%



o-hydroxy-diphenyl	Lead Sulfide	Lead Sulfide	Mercuric Oxide	Mercuric Oxide	Naphthalene
1.0%	0.1%	1.0%	0.1%	1.0%	0.1%



Naphthalene	β-naphthol	Thiokol	Selenium	Xylenol	Control
1.0%	0.1%	9.8%	0.1%	0.1%	

FIG. 5. Group 2 After Five Years' Normal Exposure

lost about 10 per cent in tensile strength; group 2 had lost nearly 40 and group 3 had lost 95 per cent. Since none of the cements had suffered serious loss of weight, and since the appearance of the briquets in groups 1 and 2 had not been seriously altered—as can be seen in Fig. 4 and 5—it may be assumed that the change in strength is not due to bacterial action but must be attributed to another cause.

As previously noted, the briquets in Pittsburgh were buried at a depth of only 18 in.; hence they were subjected,

Original Briquet ½ yr. 1 yr. 5 yr.

Normal Exposure

Original Briquet ½ yr. 1 yr. 5 yr.

Exposed to Sulfur Bacteria

Fig. 6. Aging of Group 3 Briquets

in the course of years, to alternate freezing and thawing. It may well be assumed that the effects of the latter contributed to the loss of tensile strength. The action of weathering, however, as judged by the change in tensile strength, does not seem to be progressive. After dropping to a certain value the tensile strength of the briquets seems to become stabilized and to undergo no further change. This fact indicates that, even after prolonged exposure to extreme conditions such as are not normally encountered, the cements still retain a fair, if not a major, portion of their tensile strength.

Not all the cements lost strength at the same rate. Some of the briquets—

TABLE 3

Change in Weight of Sulfur Cements

(*Normal Exposure*)

No.	Bactericide	Weight Change—*per cent*			
		Years			
		0.5	1	2	5
	Group 1				
380	Arsenous oxide*	−0.2	+0.3	+0.1	−1.1
37	Cresol-c†	+0.2	+0.6	+0.2	−1.2
378	β-naphthol†	+0.2	+0.4	0	−1.2
3	Selenium†	+0.1	+0.3	+0.1	−1.9
70	Xylenol†	+0.6	0	+0.5	−3.1
	Average	+0.2	+0.3	+0.2	−1.7
	Group 2				
387	Arsenous oxide†	−0.6	+0.8	−0.4	−0.8
0	Control	−0.1	+0.6	+0.3	−1.6
03	Copper sulfate*	+0.3	+0.6	+0.8	−1.2
73	Cresol-c*	0	+1.2	−1.9	−2.2
78	*o*-cyclohexylphenol*	−0.3	+0.4	−0.3	−1.6
87	*o*-cyclohexylphenol†	0	+0.1	+0.5	−0.6
38	*o*-hydroxydiphenyl*	+0.1	+0.6	0	−0.3
83	*o*-hydroxydiphenyl†	−1.1	+1.0	+0.3	−1.1
8	Lead sulfide*	+0.8	+1.2	0	−1.6
08	Lead sulfide†	+0.2	+0.3	−0.5	−3.2
77	Mercuric oxide*	0	+0.7	0	−1.8
7	Mercuric oxide†	+0.5	+0.6	+0.6	−1.1
88	Naphthalene*	+0.3	+0.5	0	−2.0
308	Naphthalene†	−0.8	+0.2	+0.3	−3.3
370	β-naphthol*	0	+0.6	0	−1.9
33	Selenium*	+0.5	+0.8	+0.6	−2.2
00	Thiokol‡	+0.4	+0.1	−0.3	−1.5
07	Xylenol*	−0.6	+0.8	−1.0	−1.7
	Average	−0.4	+0.6	−0.1	−1.6
	Group 3				
30	Copper sulfate†		−1.6	−1.0	−3.6

* 0.1 per cent. † 1.0 per cent. ‡ 9.8 per cent.

those containing 1 per cent of selenium—actually gained in strength. Others that contained certain organic materials soluble in sulfur also seemed to lose strength more slowly than the majority. This effect is attributed in part to the influence of the solubl material on the crystallizing propertie of sulfur. The phenomenon has bee described previously (1), and it wa noted that "Thiokol" improved the re-sistance of sulfur cements to therma

TABLE 4

Loss of Tensile Strength of Sulfur Cements
(*Normal Exposure*)

No.	Bactericide	Strength Loss—*per cent*			
		Years			
		0.5	1	2	5
	Group 1				
380	Arsenous oxide*	0	14	23	14
37	Cresol-c†	−10	12	20	13
378	β-naphthol†	11	21	27	23
3	Selenium†	−28	−6	−6	0
70	Xylenol†	6	18	30	12
	Average	−4	12	19	12
	Group 2				
387	Arsenous oxide†	13	8	−11	25
0	Control	−3	20	23	20
03	Copper sulfate*	24	40	46	44
73	Cresol-c*	24	36	36	47
78	*o*-cyclohexylphenol*	10	20	24	23
87	*o*-cyclohexylphenol†	0	24	27	33
38	*o*-hydroxydiphenyl*	14	34	47	47
83	*o*-hydroxydiphenyl†	20	33	44	43
8	Lead sulfide*	15	38	37	36
08	Lead sulfide†	1	23	33	36
77	Mercuric oxide*	24	48	46	36
7	Mercuric oxide†	16	34	42	47
88	Naphthalene*	29	44	45	49
308	Naphthalene†	31	51	59	48
370	β-naphthol*	34	41	48	49
33	Selenium*	35	38	52	45
00	Thiokol‡	3	10	22	47
07	Xylenol*	16	36	49	43
	Average	17	32	37	40
	Group 3				
30	Copper sulfate†		90	80	96

* 0.1 per cent. † 1.0 per cent. ‡ 9.8 per cent.

shock. It is interesting, therefore, to examine the briquet made with "Thiokol." Why this sample did not behave better than others is unknown, but perhaps the loss in strength may have been influenced by the large amount of sulfur used in its preparation. The strength of sulfur cements is determined by the grading of the aggregate, the voids in the aggregate and the percentage of sulfur used. As this particular cement contained 70 instead of

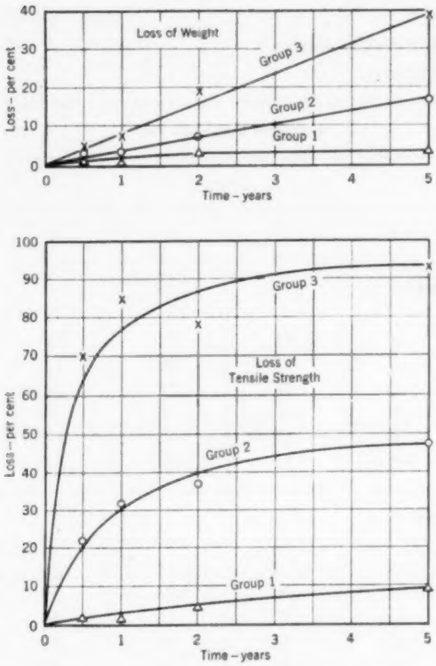
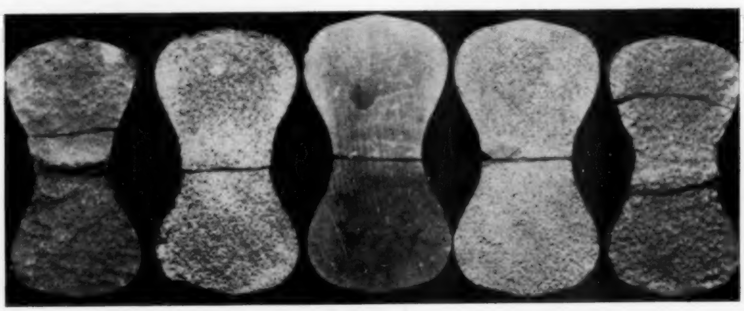


FIG. 7. Loss of Weight and Tensile Strength (Exposure to Bacteria)

Effect of Water-Soluble Salt

As it was known that sulfur cements absorb 1 per cent or more of water, and that such cements in use are constantly exposed to water, an attempt was made to incorporate only such bactericides as were essentially insoluble in water, so that they would not be removed by leaching. But two series of cements were made containing, respectively, 0.1 and 1.0 per cent of anhydrous copper sulfate, a material soluble in water. Examination of the data shows that the cement containing 0.1 per cent behaves normally, as judged by the control. The cement containing 1 per cent of copper sulfate, however, failed rapidly. Evidence of such failure is apparent not only by reference to the tensile strength data, but also on examining the physical appearance of the briquet. Most of the briquets exposed in soil in Pittsburgh were comparatively free of signs of spalling, pitting



Arsenous Oxide	Cresol-c	β-naphthol	Selenium	Xylenol
0.1%	1.0%	1.0%	1.0%	1.0%

FIG. 8. Group 1 After Five Years' Exposure to Bacteria

55 per cent of sulfur, it is suspected that the poor performance of the briquet must be attributed to this fact. The effect of an excess of sulfur is also apparent in the briquets containing arsenous oxide. The one containing 60 per cent of sulfur is inferior to the one with 55 per cent.

or crazing, but the briquets containing 1 per cent of copper sulfate, as illustrated in Fig. 6, spalled and crazed badly. This deterioration must be attributed solely to the presence of anhydrous copper sulfate which, in the presence of water, formed a series of hydrates whose volume was greater

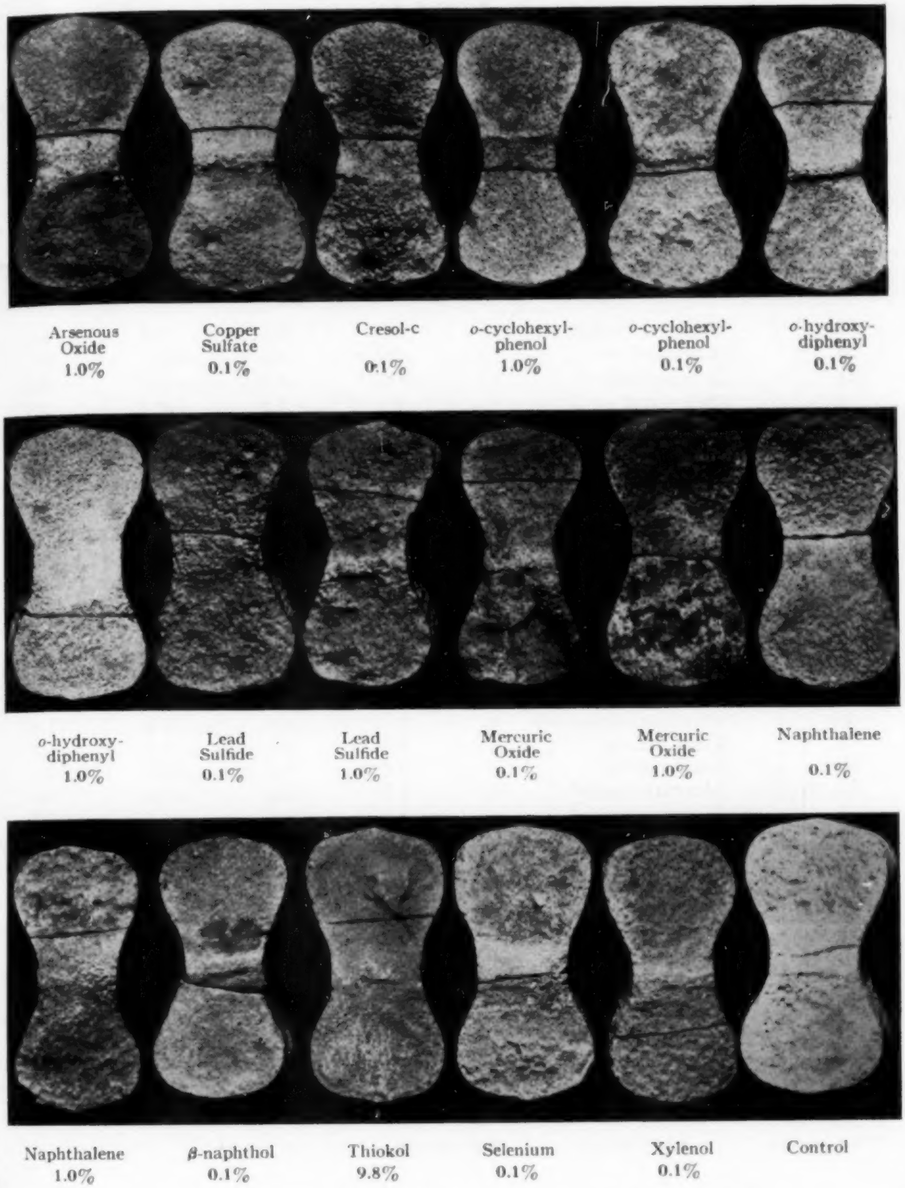


FIG. 9. Group 2 After Five Years' Exposure to Bacteria

than that of the original salt. This action caused the briquet to swell, spall and disintegrate as shown. Part of the disintegration must also be attributed to leaching.

Mock (9) has brought out that porous structures can be prepared by dispersing crystals of sodium chloride in molten sulfur, allowing the mixture to set and extracting the salt with water.

TABLE 5

Loss of Weight of Sulfur Cements

(Exposed to Bacteria)

No.	Bactericide	Weight Loss—*per cent* Years 0.5	1	2	5
	Group 1				
380	Arsenous oxide*	0.6	0.2	3.0	24.
37	Cresol-c†	2.7	2.6	11.	30.
378	β-naphthol†	*−0.4*	*−0.5*	*−0.2*	*−0.1*
3	Selenium†	0.2	*−1.3*	*−0.6*	2.5
70	Xylenol†	*−0.1*	0.2	3.5	31.9
	Average	0.6	0.2	3.3	17.4
	Group 2				
387	Arsenous oxide†	1.3	0.9	4.1	22.9
0	Control	0.7	0.5	1.8	29.4
03	Copper sulfate*	3.4	5.5	14.3	32.9
73	Cresol-c*	4.6	6.0	13.4	32.7
78	*o*-cyclohexylphenol*	5.4	7.1	16.7	31.3
87	*o*-cyclohexylphenol†	1.8	1.8	8.3	18.3
38	*o*-hydroxydiphenyl*	3.2	3.8	15.8	31.9
83	*o*-hydroxydiphenyl†	0	1.0	1.4	11.5
8	Lead sulfide*	4.9	6.2	11.3	28.3
08	Lead sulfide†	3.6	4.4	12.5	31.
77	Mercuric oxide*	1.7	3.4	13.2	37.6
7	Mercuric oxide†	3.1	2.6	1.8	21.2
88	Naphthalene*	4.7	3.7	6.4	25.1
308	Naphthalene†	1.5	2.6	8.7	35.8
370	β-naphthol*	0.2	*−0.6*	2.1	19.1
33	Selenium*	0.8	0.6	4.5	15.2
00	Thiokol‡	0.3	3.0	5.6	13.5
07	Xylenol*	0.8	0	5.5	33.3
	Average	2.3	2.9	8.2	26.1
	Group 3				
30	Copper sulfate†	5.4	7.4	19.2	39.7

* 0.1 per cent. † 1.0 per cent. ‡ 9.8 per cent.

By using graded crystals the grain or pore size of the material is controlled, and Mock was able to make either a sieve or a cellular structure. The results obtained with copper sulfate are similar to those reported by Mock and seem to indicate that incorporating water-soluble salts in sulfur cements may be deleterious.

Bacteria and Sulfur Cements

All the data respecting the sulfur cements exposed in Texas to sulfur-oxidizing bacteria have been assembled

TABLE 6

Loss of Tensile Strength of Sulfur Cements
(Exposed to Bacteria)

No.	Bactericide	Strength Loss—*per cent* Years 0.5	1	2	5
	Group 1				
380	Arsenous oxide*	13	7	24	37
37	Cresol-c†	*−12*	2	10	8
378	β-naphthol†	3	8	6	4
3	Selenium†	*−2*	*−19*	*−21*	*−10*
70	Xylenol†	7	10	5	5
	Average	2	2	5	9
	Group 2				
387	Arsenous oxide†	37	43	38	60
0	Control	12	20	29	40
03	Copper sulfate*	42	43	49	58
73	Cresol-c*	26	31	42	45
78	*o*-cyclohexylphenol*	20	17	36	43
87	*o*-cyclohexylphenol†	6	10	8	32
38	*o*-hydroxydiphenyl*	22	40	42	47
83	*o*-hydroxydiphenyl†	28	37	32	43
8	Lead sulfide*	8	36	37	46
08	Lead sulfide†	5	5	26	49
77	Mercuric oxide*	22	36	43	45
7	Mercuric oxide†	20	33	32	47
88	Naphthalene*	32	39	40	57
308	Naphthalene†	45	55	59	59
370	β-naphthol*	34	40	51	48
33	Selenium*	38	40	38	52
00	Thiokol‡	*−10*	11	34	53
07	Xylenol*	20	39	27	51
	Average	22	32	37	48
	Group 3				
30	Copper sulfate†	70	85	78	92

* 0.1 per cent. † 1.0 per cent. ‡ 9.8 per cent.

in Tables 5 and 6 and are plotted in Fig. 7. Pictures of the briquets after exposure are shown in Fig. 8 and 9. It is evident from these data that sulfur-oxidizing bacteria can have a definite effect on sulfur cements, and that the action as determined by loss in weight is progressive. Visual inspection reveals that the briquets have been etched. Surface disintegration is noted particularly in the cement containing copper sulfate, as shown in Fig. 6, but here the result must be attributed not only to the action of bac-

teria but also to the presence of copper sulfate. In five years the control and the cements classed as group 2 lost 26 per cent of their weight. Reference to group 1, however, indicates that certain classes of compounds, particularly β-naphthol and selenium, offer protection against these organisms. Whether or not xylenol and arsenous oxide can retard the action of bacteria is questionable. Judged by the loss in tensile strength, these compounds may have some retarding action. There is sufficient evidence, however, to warrant the assumption that compounds are available which will retard or prevent bacterial action, and it is hoped that further research will demonstrate those best suited for this use.

Summary

Previously data were collected to facilitate the production of sulfur cements and to aid users in appraising and applying them. In the researches described in this paper an attempt was made to determine the life or aging of such cements when buried in soil. According to the data collected:

1. Sulfur cements buried in soil in Pittsburgh, after five years' exposure, showed practically no change in weight, although there was some loss of tensile strength. This loss in strength is attributed to the fact that the cements were buried at shallow depths and subjected to alternate freezing and thawing.

2. Sulfur cements buried in soil heavily infested with sulfur bacteria were attacked by the bacteria. The action was progressive, with the result that after five years' exposure the cements lost considerable weight and nearly 50 per cent of their tensile strength.

3. The action of bacteria on sulfur cements may be retarded or prevented by the use of bactericides.

4. The incorporation of water-soluble salts, such as copper sulfate, in sulfur cements is deleterious.

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Bacterial Oxidation of Sulfur in Pipe Sealing Mixtures

By Lloyd R. Frederick and Robert L. Starkey

A paper presented on May 5, 1948, at the Annual Conference, Atlantic City, N.J., by Lloyd R. Frederick, Research Fellow, Rutgers Univ.; and Robert L. Starkey, Research Specialist in Microbiology, New Jersey Agricultural Experiment Station, and Prof. of Microbiology, Rutgers Univ., New Brunswick, N.J.*

MATERIALS containing relatively large amounts of sulfur have been used to seal joints of cast-iron water mains. The molten-sulfur sealing mixture is poured into the joints, where it forms an impervious cement. Many miles of pipes with joints thus sealed have remained intact for years and are still in good condition, but it is the opinion of some engineers that the sulfur sealing compound may break down under some conditions.

The extent of the failures is unknown to the authors, and only one report of failure has come to their attention. This report of Beckwith and Bovard (1, 2) was concerned with a 15-mile-long 20-in. cast-iron water main in California. After only one year of service many of the joints of the main had failed, and the sealing material had so disintegrated that it could be easily scraped out of the joints. The soil adjacent to the joints was wet and black with iron sulfide. It was reported that cultures of a sulfur bacterium resembling *Thiobacillus thiooxidans* and also sulfide-producing bacteria were recovered from the water and the black material near the leaking joints. Beckwith and Bovard contended that the sulfur in the sealing compound had been attacked by the sulfur bacteria and oxidized to sulfate, and that the sulfate was reduced to sulfide by sulfate-reducing bacteria. The cultures of sulfur bacteria that they obtained were, however, relatively inactive. Furthermore, recovery of the sulfur bacteria from the soils is scarcely adequate evidence that these bacteria caused the pipe failure, for the authors reported that the bacteria likewise were recovered from a garden soil. In addition, it has been reported elsewhere that the sulfur bacterium has been recovered from poorly drained soils (3) as well as from cultivated soils (4). Several other observers have also recovered it from various abnormally acid soils. Sulfate-reducing bacteria are widely distributed in soils, but they are principally active under such anaerobic conditions as are encountered in bogs, lake and ocean bottoms, and sewage.

Although the results of Beckwith and Bovard are suggestive, they are inadequate to prove that the sulfur bacteria were responsible for the failure of the sealing mixture.

* Journal Series Paper, New Jersey Agricultural Experiment Station, Rutgers Univ., Dept. of Microbiology.

Experiments

The following experiments were undertaken to determine the susceptibility of one of the sealing mixtures to bacterial attack, and to consider the possibility of incorporating in the sealing mixture substances that would preserve it against destruction by sulfur bacteria. *Thiobacillus thiooxidans* was used as the test organism, because it is one of the most active—if not the most active—sulfur-oxidizing bacterium found in soils.

Influence of Particle Size and Area

The relatively small surface area per unit weight of sulfur in pipe joints has

TABLE 1

Acid Production in Media Containing Different Amounts of Sulfur

Amount of Sulfur *g.*	Titer at Different Incubation Periods		
	4 days	11 days	29 days
	ml. 0.1 *N* NaOH for 5-ml. Medium		
0	0.1	0.1	0.1
1	2.4	13.2	13.1
2	3.3	19.4	19.5
5	2.2	20.9	21.5
10	2.0	15.8	28.0
25	1.3	9.6	34.2

a marked effect on sulfur oxidation, for it has been shown previously (5, 6) that oxidation is increased by increasing the exposed area of sulfur.

In an additional experiment, precipitated sulfur was added to 100-ml. portions of an inorganic culture solution (6) in amounts from 1 to 25 g. Flasks of the sterile media were inoculated with *T. thiooxidans,* incubated, and tested periodically for increase in acidity resulting from oxidation of the sulfur. As shown in Table 1, acid production increased with greater amounts of sulfur in the medium, after the first few days of incubation.

Additional evidence concerning the effect of surface area on oxidation was obtained from tests in which the particle size of the sulfur was varied (Fig. 1). Rhombic sulfur was passed through screens to obtain particles

TABLE 2

Oxidation of Sulfur and Sulfur Mixtures

Incubation Period *weeks*	Titer—ml. 0.1 *N* NaOH for 5-ml. Medium		
	Sulfur	Sulfur-Silica-Carbon Mixture	Sealing Compound
	1-cm. Cubes		
0	0.1	0.1	0.1
1	0.3	0.3	0.2
5	0.9	0.7	0.6
10	1.6	1.3	1.0
18	3.2	2.8	2.1
44	6.7	4.7	3.6
	Pulverized Material		
0	0.1	0.1	0.1
1	5.6	3.6	0.1
3	17.2	11.7	0.1
6	19.0	14.7	7.6
8	19.6	15.0	13.5

varying in cross section from 10–30 mm. to less than 0.05 mm. The sulfur was supported on glass wool to keep it on the surface of the medium, for otherwise the coarse particles would have settled to the bottom of the flasks, where the rate of sulfur oxidation would have been exceedingly slow. Two-gram portions of the sulfur fractions were placed in flasks of the solution medium. (The horizontal lines in Fig. 1 indicate the range of sizes of the sulfur particles in each fraction.)

As shown by Fig. 1, there was an almost linear decrease in sulfur oxidation with an increase in the logarithm of the size of particles less than 1.3 mm. in diameter. Oxidation continued at a slow rate with particles larger than this.

Further information concerning the influence of particle size was obtained from tests of a commercial sealing mixture composed of 58 per cent sulfur, 39.95 per cent silica, 1.2 per cent Thiokol,* 0.8 per cent carbon black and 0.05 per cent phosphorus pentasulfide. The various substances associated with the sulfur increased the strength and elasticity of the mixture.

Cubes of this sealing mixture, 1 cm. in size, were prepared from molten material. Similar cubes were prepared of sulfur alone and of a mixture of sulfur (59.2 per cent), silica (40.0 per cent) and carbon black (0.8 per cent). These cubes were supported on glass wool in a solution medium so that part of the sulfur projected above the surface of the medium. Additional tests were made with similar sulfur materials that were finely pulverized. As shown by the results summarized in Table 2, the amounts of acid produced from the cubes of sulfur by *T. thiooxidans* on prolonged incubation were exceedingly small. With finely divided sulfur, nearly as much acid was produced in one week as from the sulfur cubes in 44 weeks. Somewhat less acid was produced from the cubes in which the sulfur was mixed with other materials. This fact is ascribed to dilution and coating of the sulfur with the other constituents of the mixtures. Other experiments indicated that the constituents had little, if any, toxic effects.

* Polymer of polyethylene sulfide. The material before polymerization is referred to as "Tegul O."

It is evident from the results that, although pulverized sulfur is oxidized rapidly, massive sulfur is only slowly transformed. The presence of a large amount of other materials with the sulfur in the sealing mixture further decreases its susceptibility to attack.

Inhibitors in Medium

Because the sulfur in the sealing compound might be attacked by sulfur bacteria in the soil, consideration was given to the use of germicides to control bacterial development. In several series of tests, the substances were in-

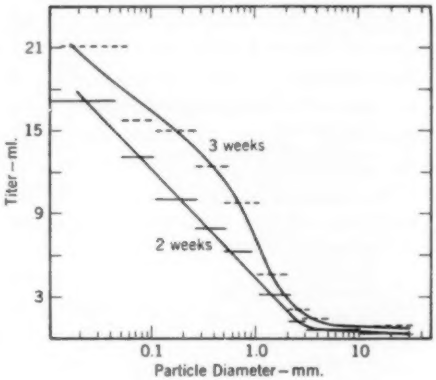

FIG. 1. Effect of Particle Size on Sulfur Oxidation

corporated in the inorganic solution medium customarily used to grow *T. thiooxidans*. The solution medium containing the substance was used in 100-ml. portions in 250-ml. Erlenmeyer flasks. One-gram portions of sterile precipitated sulfur were added to the flasks of the sterile solution medium, after which the flasks were inoculated with an active culture of *T. thiooxidans* and incubated at 28°C. Periodically the amounts of sulfuric acid produced from sulfur oxidation were determined. Several experiments were conducted in which the inhibitive

effects of various organic and inorganic materials were determined for incubation periods of from two to seven weeks.

Compounds with little or no inhibitive effect at a concentration of 1,000 ppm. included: copper sulfate, cupric chloride, chromic chloride, lithium sulfate, sodium selenate, sodium arsenate, lead acetate, zinc sulfate and naphthalene. Tegul O had no inhibitive effect at 1,000 ppm. Thiokol inhibited oxidation by only 40 per cent at 1,000 ppm. and had no apparent effect at 100 ppm.

The results obtained with various organic and inorganic materials that showed some evidence of toxicity are summarized in Table 3. Many compounds completely prevented oxidation at 1,000 ppm.; somewhat fewer, at 100 ppm.; and none appreciably affected oxidation at 1 ppm. There were considerable differences in the inhibitive effects of the various phenolic compounds, some of which were relatively toxic at 10 ppm. while others showed no toxicity at 100 ppm. The two dyes, crystal violet and acriflavine, had a relatively high degree of toxicity.

TABLE 3

Effects of Various Materials on Sulfur Oxidation by T. thiooxidans

Substance	Incubation Period *weeks*	Concentration (*ppm.*) 1,000	100	10	1
		Inhibition—*per cent*			
o-cresol	2	100	0	0	0
2-hydroxy-1,4 dimethylbenzene	2	100	66	32	0
β-naphthol	2	100	100	38	0
o-hydroxydiphenyl	2	100	100	39	0
o-cyclohexylphenol	2	100	100	29	0
Monoamylphenol	5	100	98	0	0
Diamylphenol	5	61	0	0	0
Monobutylmetacresol	5	100	0	0	0
Catechol	5	87	74	0	0
Mercaptoethanol	5	96	0	0	0
Picric acid	2	100	100	53	0
Crystal violet	2	100	100	33	0
Acriflavine hydrochloride	4	100	100	67	0
Sodium azide	7	100	100	0	0
Sodium iodoacetate	7	100	100	0	0
Sodium fluoride	4	100	100	0	0
Sodium silicofluoride	7	100	97	0	0
Sodium arsenite	4	100	83	74	0
Sodium selenite	4	100	100	0	0
Potassium tellurite	4	100	59	0	0
Copper acetate	2	100	100	22	0
Mercuric chloride	2	100	100	100	0

Some materials used to inhibit bacterial assimilation were included in the tests. These were: sodium azide, sodium iodoacetate, sodium fluoride, and sodium arsenite. They were about equally toxic, except that sodium ar-

senite was more toxic at 10 ppm. than the others. Vogler, LePage and Umbreit (7) also determined the effects of these and several other inhibitors on the growth of *T. thiooxidans*. They reported that growth was completely inhibited by 2 ppm. of sodium iodoacetate or sodium nitrite, 42 ppm. of sodium fluoride or 65 ppm. of sodium azide.

Sodium selenite and potassium tellurite were also relatively toxic, the former more so than the latter. Additional tests were made with metallic selenium and tellurium in which the pulverized metals were used in the culture medium either alone or together with elemental sulfur. Neither selenium nor tellurium supported the growth of *T. thiooxidans*. In media containing sulfur, selenium had no apparent effect on growth and sulfur oxidation, but tellurium completely inhibited sulfur oxidation. In other tests, a sample of sulfur that contained 300 ppm. of selenium was as rapidly oxidized by the bacterium as was pure sulfur.

Inhibitors in Sulfur

A germicidal substance should have the following characteristics in order to be a satisfactory inhibitor for use in the sulfur sealing mixture: it should not be inactivated by the sulfur; it should be readily dispersed in the sealing mixture; it should be released in amounts sufficient to inhibit sulfur oxidation over a long period; and it must not be a health hazard when used to seal joints in water mains. Many of the compounds tested would not meet these specifications. Whether or not any of the substances would be satisfactory under field conditions remains to be determined.

To test the effects of the inhibitors mixed with the sulfur, the materials were added in appropriate amounts to molten sulfur kept at approximately 120°C. When the materials appeared to be uniformly mixed, the molten mass was poured on a clean enamel surface, where it cooled. The solidified materials were pulverized, added to flasks of the inorganic solution medium and tested for oxidation by *T. thiooxidans*. Some of the results of the tests are included in Table 4.

Certain materials had no appreciable toxicity even at a concentration of 1 per cent. Both crystal violet and sodium pentachlorphenate completely inhibited growth at both 0.5 and 1.0 per cent. Some of the materials that had relatively high toxicity when used in the culture medium were relatively nontoxic in sulfur. For example, β-naphthol and *o*-hydroxydiphenyl dissolved in the culture solution inhibited growth at 100 ppm. but, when incorporated with the sulfur, failed to inhibit growth even at 10,000 ppm. (1 per cent) in one case and at 5,000 ppm. (0.5 per cent) in the other. Three of the other phenolic compounds completely inhibited growth at a concentration of 1 per cent. Although iodine completely inhibited oxidation at both concentrations, it is not well suited for use in the sulfur because it tends to volatilize.

Results with a few additional compounds are included in Table 5. Tests were made with both static and shaken media, for it was found that some of the substances caused the sulfur to wet readily and to sink to the bottom of the flasks; under this condition oxidation was very slow. As shown by the data, only one substance appreciably inhibited growth at concentrations of less than 5,000 ppm. Growth was

meagre at 5,000 ppm. with sodium silicofluoride and temporarily inhibited with metallic tellurium. Sodium pentachlorphenate was outstanding because it completely inhibited growth at 500 ppm. and caused a delay in oxidation at 100 ppm. Iodine had little or no protective effect even at a concentration of 10,000 ppm. The container in which the iodine-containing sulfur had been stored for several weeks before being used showed evidences of volatilization of iodine. This is believed to be the reason for the different results in Tables 4 and 5.

TABLE 4

Toxicity of Some Materials Incorporated in Sulfur

Substance	Concentration *per cent*	Inhibition—*per cent*	
		1 week	4 weeks
Resorcinol	0.5	0	0
	1.0	0	0
Sodium *o*-phenylphenate	0.5	0	0
	1.0	0	0
Tegul O	0.5	66	0
	1.0	66	15
o-cresol	0.5	27	0
	1.0	21	0
2-hydroxy-1,4 dimethylbenzene	0.5	47	0
	1.0	50	0
Phenol	0.5	23	0
	1.0	37	0
o-phenylphenol	0.5	48	5
	1.0	97	61
β-naphthol	0.5	94	0
	1.0	96	32
o-cyclohexylphenol	0.5	43	0
	1.0	100	100
o-hydroxydiphenyl	0.5	68	13
	1.0	100	100
o- and *p*-benzylphenols*	0.5	63	74
	1.0	100	100
Crystal violet	0.5	100	100
	1.0	100	100
Sodium pentachlorphenate†	0.5	100	100
	1.0	100	100
Iodine	0.5	100	100
	1.0	100	100

* A product of the Monsanto Chemical Co., named "Santophen 7."
† A product of the Monsanto Chemical Co., named "Santobrite."

The tests of inhibitors were very much accelerated, because the sulfur was always present in the media as finely pulverized material. With the sulfur in massive form, as it would be in pipe joints, the germicides would doubtless exert considerably greater protection than that observed in these experiments.

Conclusions

Studies of the inhibitive effects of various organic and inorganic materials on the oxidation of sulfur by *Thiobacillus thiooxidans* have been

made with particular regard to controlling the oxidation of sulfur used to seal joints of pipes that are to be kept underground.

The one sulfur sealing compound that was tested was found to be susceptible to attack by *T. thiooxidans*, but oxidation of the sulfur was exceedingly slow unless the material was pulverized. Even in this condition it was not so rapidly oxidized as pure sulfur.

The rate of oxidation of sulfur by the sulfur bacterium *T. thiooxidans* is affected by the size of the sulfur particles. The larger the particles of sulfur, the slower the rate of oxidation. Sulfur contained in sealing material in pipe joints would be expected to oxidize at an exceedingly slow rate compared to pulverized sulfur because of the small amount of surface exposed. In a failure of the sealing compound in joints of a water main, reported to have been caused by sulfur bacteria, the evidence that was presented is inadequate to prove the contention. There is no indication of whether such failures are common or whether this was an isolated incident.

TABLE 5

Inhibition of Sulfur Oxidation by Some Substances Incorporated in Sulfur

Substance	Concentration ppm.	Inhibition—per cent			
		Static Media		Shaken Media	
		1 week	4 weeks	1 week	4 weeks
Iodine	10,000	45	45	0	0
	5,000	0	0	0	0
Sulfur chloride	10,000	80	76	0	0
	5,000	85	76	0	0
	1,000	71	64		
	500	0	0		
Tellurium	10,000	100	100	100	100
	5,000	63	0	100	61
	1,000	0	0	91	0
Sodium silicofluoride	10,000	100	100	100	100
	5,000	49	62	74	88
	1,000	0	0	0	0
Sodium pentachlorphenate	10,000	100	100	100	100
	5,000	100	100	100	100
	1,000	100	100	100	100
	500	100	100	100	100
	100	93	67	100	40

If there are failures due to bacterial oxidation of the sulfur, it may be possible to preserve the sulfur by incorporating some inhibitive material in the sealing mixture. Numerous substances have been tested for their inhibitive action on the development of *T. thiooxidans*. The most effective of these was sodium pentachlorphenate, which completely prevented sulfur oxi-

dation in accelerated culture tests when incorporated in the sulfur at a concentration of 500 ppm. and which had some protective effect at 100 ppm. Other materials with somewhat less inhibitive effects were crystal violet, acriflavine, sodium fluoride, sodium silicofluoride, sodium azide, sodium iodoacetate, sodium arsenite, tellurium, sodium selenite, potassium tellurite and various phenolic compounds such as a mixture of *o*- and *p*-benzylphenols, *o*-hydroxydiphenyl and *o*-cyclohexylphenol.

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Sulfur Jointing Compounds—A Panel Discussion

By Wendell R. LaDue, Thomas F. Wolfe, Martin E. Flentje, C. R. Payne, Joseph P. Schwada, Guy C. Northrop and W. Victor Weir

A panel discussion presented on May 5, 1948, at the Annual Conference, Atlantic City, N.J., by Wendell R. LaDue, Supt. and Chief Engr., Bureau of Water and Sewerage, Akron, Ohio; Thomas F. Wolfe, Research Engr., Cast Iron Pipe Research Assn., Chicago; Martin E. Flentje, Research Engr., American Water Works Co., Inc., New York City; C. R. Payne, Vice-Pres. and Technical Director, Atlas Mineral Products Co., Mertztown, Pa.; Joseph P. Schwada, City Engr., Milwaukee, Wis.; Guy C. Northrop, Pres., Northrop & Co., Inc., Spring Valley, N.Y.; and W. Victor Weir, Pres., St. Louis County Water Co., University City, Mo.

Wendell R. LaDue

IN presenting this panel discussion on sulfur jointing compounds—or perhaps one should say lead-substitute joint material—the principal purpose is to bring openly before the members of the Association a subject which for some time has been discussed informally by many widely separated water works men. It appears desirable and beneficial to all concerned to obtain an account of the experience of users, as well as to secure an explanation of possible causes of failure from both the manufacturers and the users of jointing materials. In such a discussion, the valuable knowledge of the manufacturers of cast-iron pipe is to be earnestly solicited.

Viewed in the light of experience, the subject really breaks down into three problems, perhaps distinct, perhaps related:

1. The disintegration of the jointing material [the papers by Duecker *et al.* and by Frederick and Starkey (*see* pp. 715 and 729, this issue) have added valuable data to this phase of the subject]

2. The corrosion of the pipe itself, especially in the spigot portion of the joint

3. The breaking of pipe bells, with the attendant fracture extending along the pipe.

Akron Experience

Akron experience has been confined primarily to the latter two problems, involving lead-substitute joint material in centrifugally cast pipe. Lead-substitute joint material in limited quantity was first used by the private water company at Akron, previous to the acquisition of the property by the city in 1912. A few mains were laid in the 1920's using this type of material. About 1930 the department adopted a policy of using lead-substitute joint material almost exclusively for its water main construction. Much lead is used in repair work. Since 1930 over 200 miles of water mains, comprising

at least 100,000 joints, have been laid using substitute material.

Akron's first experience with the problems under discussion occurred in 1944 when a hydrant run broke near a lead-substitute joint. Examination showed pitting on the spigot of the pipe. Soon thereafter a similar break occurred at the joint of an 8-in. main. Characteristic pitting was again reported. The department's curiosity being aroused, the adjacent joint, which also showed pitting, was removed and cut into several parts and sections which were sent to interested persons. A visual examination of the joint indicated that the corrosion on the surface of the spigot extended inside the joint to the point where the packing started. Pitting of the pipe was also evident at the face of the bell on the spigot end. The 6-in. hydrant run was in relatively dry soil, while the 8-in. main was in soil showing some dampness. All of these pipes had been in place less than five years. In a subsequent investigation numerous joints were uncovered at widely separated locations. Some of these showed pitting and corrosion in varying degrees of severity, but no conclusion on the effects of soil conditions could be drawn, because the pitting had occurred and been absent indiscriminately in dry, wet, sandy, clayey, mucky, rocky and filled ground.

Representatives of the cast-iron pipe industry, examining the location of the 8-in. main break, reported that the soil conditions were satisfactory and not necessarily conducive to disintegration or corrosion. The joint material manufacturers' representatives seemed to feel that the damp soil had no bearing on the condition of the compound.

Akron's most serious, annoying and expensive experiences have been in the breaking of bells. The failures are all similar and, strangely, occur principally in pipe of 12-in. size. The bell simply cracks for no apparent reason and opens about ¼ in., after the water pressure has been released. The crack extends in a spiral for approximately 4–8 ft. along the top, side or bottom of the pipe. Real damage occurs to the pavement and adjacent properties. There have been ten such breaks in a 3,800-ft. section of 12-in. main laid in 1942. Several similar breaks in other 12-in. mains have occurred throughout the past few years.

Temperature stress seems to have no effect, since breaks have occurred at all seasons. Field inspection at breaks has eliminated the possibility of poor alignment, faulty pipe laying and backfilling as causes. Excellent trench material and conditions prevailed. The possibility of "push" stresses on pipe laid on a grade was suggested, but several breaks have occurred in perfectly level ground. The pipe manufacturers have viewed several breaks on the ground and have subsequently examined pipe removed at the break, subjecting it to standard laboratory tests for pipe and pipe material without arriving at any explanation.

Akron's difficulties with lead-substitute joints have been quite recent (dating from 1944) and relatively small in proportion to the number of joints involved. The department is vitally interested, however, in obtaining more tangible information on a problem which is not only confusing but definitely annoying. As the city of Akron expects to embark upon a pipe laying program (as soon as pipe deliveries

are assured) involving many miles of 12-in. and larger cast-iron pipe, a jointing material which will insure a satisfactory joint life and corrosion factor is of the utmost importance. The Akron water bureau maintains an open and at the same time inquiring mind on the subject, desiring simply that the mains have the opportunity to give the unhampered service of which they are capable.

Thomas F. Wolfe

The cast-iron pipe industry is of the opinion that the choice of jointing materials and methods to be used with bell-and-spigot pipe should be in the hands of the water works operator. Since one of the principal characteristics of cast-iron pipe is long life, the industry is, of course, concerned by anything that would tend to affect this longevity. Consequently, the industry is interested in ways of overcoming any corrosion which may be caused by sulfur compound jointing materials.

Although it is true that in a number of places corrosion and sulfur-compound jointing materials seem to be related, it is also true that in many other localities where similar jointing practice has been followed, no corrosion troubles have been reported. The logical conclusion would seem to be that the compounds by themselves are not entirely at fault, but that the difficulty arises from a combination of the sulfur compound and some soil condition.

In the examples that have come to the attention of the cast-iron pipe industry—with only one exception—the corrosion traceable to the use of sulfur compounds appears to have been of the anaerobic variety, a type which is usually limited to heavy, wet soils. The one exception referred to occurred in a dry, sandy soil, but it is felt that insufficient information is available to determine whether this failure was caused by the jointing material or by other conditions.

Where anaerobic corrosion has occurred, three remedies suggest themselves: (1) using a bactericide in the compound to eliminate bacterial action; (2) changing the environment around the joint by the use of sand backfill, in order to aerate the joint and discourage bacterial action; and (3) using some jointing material other than a sulfur compound in soils of this particular type.

Though split bell failures are a rare occurrence, the fact that under like conditions, even in the same water system, there are more failures of this type where sulfur compounds are used than where lead is employed would lead to the conclusion that the compound contributed to the failure. The remedy is not to increase bell strength in order to be able to handle the stress caused by the expansion of the jointing material, because this procedure, if followed, would add to the cost of the pipe for all consumers whether or not they use sulfur compound jointing materials. The logical solution is to adjust the composition of the compound in such a fashion that bell strains will be eliminated, if an adjustment of this kind is possible.

It appears that sulfur-compound jointing materials have been used for so long and in such widely scattered areas as to make it feasible, by means of a simple research program, to determine the types of soil where no trouble has been experienced, as well as the types where the corrosion of pipe or the disintegration of joint ma-

terials has occurred. If this information is gathered and correlated, it should be possible to predict beforehand whether or not sulfur compounds ought to be used in any particular location.

Martin E. Flentje

The use of sulfur jointing compounds in cast-iron water mains, although generally satisfactory, has not been without some failures and troubles. In the American Water Works Co. properties these difficulties have fallen into four categories: (1) failure of joints through crumbling and disintegration shortly after the laying of the lines (this has not happened in the past 25 years, but at one time was a source of considerable financial loss); (2) failure of joints through disintegration of the compound after the joints have been in service for some time; (3) bursting of bells; and (4) pitting of the pipe either near the joint face or under the joint material.

The first category probably requires no further discussion in this paper. In passing, however, it should be remarked that no good explanation was ever offered for these costly failures, most of which were on raw-water lines.

Disintegration of Older Joints

Joint failures caused by disintegration after a considerable period of service in the ground appear to be limited to wet, marshy locations, particularly in areas where the ground water is of a saline character and where sulfides seem to be present. The percentage of this type of failure (to total joints in service) is low, but this fact (as in other sulfur-compound joint failures) is of little comfort to the operator who has this problem to contend with. Although bacterial action appears to explain this type of failure, no definite proof of the correctness of the theory is at hand.

TABLE 1

Repairs of Mains at Birmingham

Main Size *in.*	Length *mi.*	Repairs				
		Total	Joint Leaks		Broken Bells	
			No.	*per cent*	No.	*per cent*
8	7	59	34	57.6	25	42.4
12	14	164	62	37.8	102	62.2
16	4	47	45	95.8	2	4.2
Total	25	270	141	52.2	129	47.8

Breaking of Bells

The bursting of bells in cast-iron pipe in which a sulfur compound was used is another source of trouble. This type of failure is almost entirely absent in most locations, but in at least one of the American Water Works Co. subsidiaries (Birmingham), it has occurred too often to be lightly dismissed. For 25 miles of main, out of a total of 88 miles laid in the period 1926–30, on which a rather detailed study was made, there is a record of 270 repairs

between the time of the laying of the pipe and the end of 1943. Of these 270 repairs, 141 were joint leaks and 129 broken bells, as shown in Table 1.

Taking the Birmingham system as a whole, repairs have averaged one per year for every two miles of distribution mains; taking the compound-joint mileage alone, such repairs have occurred twice as frequently—one per year per mile of main. During the period under discussion, no bell breaks occurred in lead-calked joints. No good explanation for this type of failure, either in Birmingham or elsewhere, has been found.

Corrosion and Pitting

During 1947–48 approximately twenty compound joints, varying in age from 14 to 40 years, were cut out of the distribution systems of American Water Works Co. subsidiary companies for examination and analysis of the joint material. Only Hydrotite and Leadite are represented in the results shown in Table 2, because no other materials were used at the time these mains were laid. In practically all the samples, some corrosion in the form of pitting was found. Sometimes these pits occurred on the spigot just in front of the joint face; both bell and spigot almost always showed pitting at the compound-jute interface; and in other samples nearly the entire area of the spigot piece under the compound in the joint was corroded to some extent. If it is assumed that the pitting will not proceed faster than the rate indicated up to the time of removal, then the pitting found was serious in the systems of only two companies. Even in these, it should be pointed out, similar graphitic corrosion has occurred rather commonly on the

TABLE 2

Summary of Pitting Data

Company	Material	Main Size *in.*	Age at Removal *yr.*	Depth of Deepest Pit *in.*	Indicated Life of Pipe *yr.*	Iron in Compound		
						Joint Face	Joint Center	Next to Jute
						per cent		
A	Leadite	6	20	$\frac{9}{64}$	57⅓	32.50	40.00	35.00
B-1	Hydrotite	6	14	$\frac{5}{64}$	90	4.00	0.63	5.00
B-2	Leadite	6	21	$\frac{3}{64}$	223	0.63	2.50	25.00
C	Hydrotite	6	17	$\frac{6}{64}$	90			
D-1	Leadite	4	31	$\frac{8}{64}$	139	25.00	100.0	20.00
D-2	Hydrotite	6	21	$\frac{3}{64}$	247	1.25	2.50	10.00
E-1	Hydrotite	6	23	$\frac{6}{64}$	214	5.00	2.50	6.25
E-2	Leadite	6	32	0	∞ *	1.25	1.25	5.00
F	Leadite	6	40	0	∞ *	0.25	0.13	0.50
G	Leadite	6	21	$\frac{12}{64}$	48.6			31.25
H	Leadite	6	17	0	∞ *	7.50	2.50	12.50
I	Leadite	6	17–20	$\frac{5}{64}$	106–125			
K-1	Leadite	4	23	0	∞ *	16.25	2.50	7.50
K-2	Hydrotite	6	17	0	∞ *	5.00	3.75	27.50

* Infinite life—no failure through pitting action.

run of the pipe away from the joint. The corrosion is, however, considerably aggravated at and under the joint and is more serious in sulfur-compound joints than in those sealed with lead.

The pitting or corrosion near the jute appears to be of bacterial origin. Bacteria or, more probably, galvanic action between the iron sulfide in the joint material and the iron of the pipe —in which the iron is the corroding anode and the sulfide the protected cathode—appears to be a logical explanation for this difficulty.

In one company this type of corrosion, in the form of pitting at the face of the joint (in the spigot piece of the pipe), was serious enough to require the cutting off of 6 in. of the affected pipe when the line was re-laid. This pitting took place within six years or less.

Summary

In conclusion, it seems apparent that sulfur main jointing compounds are satisfactory in a large majority of locations. There are conditions under which these compound materials appear to be responsible for, or to aggravate, conditions leading to operating failures—of which the breaking of bells and the pitting of cast-iron pipe are the most important. It is unfortunate that the reasons for the failures mentioned are not more definitely known, and the Association can perform a real service in sponsoring an impartial study of these causes.

C. R. Payne

It is doubtful whether the members of the A.W.W.A. realize the great amount of research that has been done on sulfur cements. For example, complete information has been published (1) regarding their chemical resistance. It is known that sulfur cements are at least equal to lead in their resistance to acids and corrosive salts and are superior to cast iron or Portland cement. In another publication (2) it was shown that sulfur could be plasticized to increase its resistance to mechanical and thermal shock and reduce its coefficient of expansion. Information is available on the proper grading of aggregates to produce a sulfur cement of maximum density. These properties are of importance when the cements are used to join large-diameter pipe and when the pipeline passes under a railroad or over a bridge where resistance to vibration is a factor. Provisional methods for testing sulfur cements have been published (3), which make it possible for the engineer to evaluate the various cements on the market and set up his own standards for purchasing.

For over ten years there has been more or less interest in the possibility of sulfur cement being disintegrated by sulfur-oxidizing bacteria. Only one such failure has been reported by Beckwith and Bovard (4) and the data presented by them are inadequate to prove that the failure was caused by bacteria. If this is a problem, then it has been solved by the research reported by Duecker *et al.* and by Frederick and Starkey (*see* pp. 715 and 729, this issue). The manufacturers of sulfur cements and the engineers using these materials should be very grateful to the Texas Gulf Sulphur Co. which made possible this long research program.

At Newgulf, Tex., near one of the sulfur vats, a soil was found which was well contaminated with sulfur-oxidizing bacteria, and optimum conditions for the growth of these organisms existed. It seems very doubtful that

these conditions would be duplicated on any water line. Yet sulfur cement containing β-naphthol was not attacked over a period of five years, whereas sulfur cements containing no germicide were slowly attacked. Frederick and Starkey carried on these experiments in the laboratory under ideal conditions for the growth of sulfur-oxidizing bacteria and found several germicides which were superior in some respects to β-naphthol.

This research provides the necessary information to allow the manufacturer to produce a sulfur cement which will be immune to the attack of sulfur-oxidizing bacteria. The Atlas Mineral Products Co. has been adding the germicide sodium silicofluoride to its compound for almost a year. This germicide is practical to use because: (1) it is not inactivated by sulfur, either in the molten or solid state; (2) it is readily dispersed in the sealing mixture; (3) it is substantially insoluble in water; (4) it does not give off fumes which are toxic or unpleasant; and (5) it does not present a health hazard.

The effect of adding substantial quantities of water-soluble salts to sulfur cements was also described in the Duecker paper (*see* p. 724, this issue). Atlas does not add an ingredient of this nature to its cement and all of the materials are purchased according to rigid specifications and are carefully analyzed before use.

Causes of Corrosion

Corrosion is another difficulty but its causes are so many and varied that the solution to it still lies ahead. The corrosion and pitting of cast-iron water lines is a serious problem, at least in certain localities, whether the pipe is joined with sulfur cement, lead or Portland cement. For example, Scofield and Stenger (5), in 1914, showed that certain dissimilar soils, when kept moist and in contact with the same metal, caused active local corrosion and generated a considerable difference in potential, because variations in the soluble constituents formed an electrolytic cell. Such corrosion may occur in practice when trenches are backfilled with a mixture of different soils.

Pipe in contact with two solutions of the same salt of different concentrations sets up a concentration cell which causes pitting of the pipe. If the line is in a clay soil, the slow diffusion of water may give rise to a salt concentration cell. Dissolved oxygen also varies in concentration from point to point in soil water, causing a difference in potential and corrosion of the pipeline.

Carbon in cast iron may exist in the form of graphite flakes or as combined carbon. Graphite flakes are cathodic to iron and accelerate corrosion, especially in salt solutions. In certain kinds of soil water the solution of the metal becomes very rapid along the graphite flakes and results in the so-called graphitization of iron.

Severe pitting of pipe may be caused by galvanic couples or by stray-current electrolysis. To avoid electrolysis by stray currents, it is not certain whether it is better to have a joint in the water line which is a conductor or a nonconductor. Sulfur cement and Portland cement joints are not good conductors, but it should not be a difficult problem to make such a joint conduct electricity if this is desirable.

Starkey has published (6) some very interesting information on anaerobic corrosion of iron in soil. Steel and cast iron corrode in soil under anaerobic conditions even where stray current electrolysis, high acidity or galvanic

couples do not occur. The evidence indicates that bacteria play an important role in anaerobic corrosion.

Since the possible causes of corrosion of cast-iron pipelines are so numerous, the solution of this problem depends upon successful research in many fields. The question of whether or not the corrosion of pipelines is increased by joints made of sulfur cement, lead or Portland cement is being thoroughly investigated at present.

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Joseph P. Schwada

Observations of the condition of underground materials of the Milwaukee distribution system in the last few years show that some joints made with sulfur jointing compounds have so disintegrated that a comparatively short service life is indicated.

The disintegration can be classified into two types: (1) the graphitization of the cast-iron adjacent to the joint; and (2) the loss of sulfur from the jointing material.

The graphitization or loss of iron from the piping and accessories was observed to take place in various locations adjacent to the joint. Usually graphitization was greatest in the top half of the piping. The location where the graphitization was most severe and critical was in the top of the spigot directly below the point where the base of the pouring cone or cones had rested. Other areas of graphitization observed were in the spigot and bell adjacent to both the interior and exterior face of the jointing material and more or less completely around the circumference. Graphitic corrosion was also noted on the face of the bell where the pouring cone had been in contact with the cast iron.

No corrosion of this type has been found in connection with lead joints even though located in close proximity to sulfur-compound joints in which disintegration was noted. In some valves and fittings where lead was used on one side and the sulfur-compound joint on the opposite side, disintegration was absent at the lead joint but was observed at the sulfur-compound joint.

The depth of the pits caused by graphitization under the pouring cone and in other areas was measured and recorded where practical. Sketches showing the location and the extent of corrosion were also made, and at times photographs were taken as a matter of record.

Chemical analyses were made of the jointing materials in a limited number of joints which had been in service ten years or more. Some of the analyses disclosed a decided reduction in the sulfur content of the materials. The lower sulfur content was found near either the interior or exterior face of

the jointing material. Where the sulfur content was low, it was also noted that the physical characteristics had deteriorated so that the jointing material could be removed from the joint with a stick or pocketknife.

Observations were made of the soils surrounding the joints. In general, the soils vary from those in old industrial areas in the valley to those in high, well-drained and only partially developed meadow areas. Much of the soil is Miami clay. A few pH determinations and resistivity measurements were made but were not considered significant in explaining the corrosion observed. No laboratory investigations were made to determine the presence or absence of sulfur-consuming bacteria in the soil.

It might be of interest to mention also that, when the investigation was started, a sulfur-compound pouring cone was removed from the ground adjacent to the main. The pouring cone had so disintegrated that only a crystalline structure about the diameter of a thin lead pencil was found in the center.

Over a period of years electrolytic corrosion in cast-iron mains with lead joints was observed. Such corrosion was found in various places along the pipe and was never confined only to the bell and spigot of the same lead joint, which was contrary to the experience with the sulfur-compound joints. The immediate cause of the electrolysis was determined and provisions were made for its removal.

It does not seem likely that electrolysis is a factor in the corrosion of sulfur-compound joints. Stray currents—that is, those incidental to electrolysis—originate over the area served by the various electrical systems and flow to established drainage points located in generating stations and substations. The direction of flow of these currents, once established, usually remains fixed. It is also known that graphitic corrosion occurs where the electric current leaves a cast-iron water main. The observations made indicate that the graphitization of sulfur-compound joints often takes place in both the bell and spigot of the same joint. This apparent disagreement between the known phenomena of electrolysis and the observations makes it seem logical that electrolysis is not a factor. Moreover, graphitic corrosion has been observed in localities where there is no reason to suspect electrolysis.

In Milwaukee there is a committee, consisting of representatives of the several public utilities, which periodically makes tests in the field to determine the presence of stray electric currents. According to the committee secretary, measurements taken recently indicate that the pipe was negative to the surrounding structures and earth.

There is also no reason to believe that the corrosion observed in the system in Milwaukee is due to a misapplication of the sulfur jointing compounds. The first water main laid with a sulfur jointing compound was constructed with the assistance of an engineering representative of the company that furnished the compound. The representative supervised the heating of the material and the pouring of the joints and later worked with the various contractors on other installations. It is believed, therefore, that proper supervision was employed in the field.

The installation of sulfur-compound joints in the Milwaukee distribution

system was discontinued in January 1946, and the sulfur compounds are not being used at the present time.

In submitting these comments, the author wishes to acknowledge the splendid help and advice of his assistant, Arthur Rynders, under whose supervision the investigation was made. It is proposed to continue the study of the situation in Milwaukee. If joints are found to be disintegrating in areas where permanent pavements have not been laid down, it is contemplated that the joints will be replaced before the pavement is constructed.

Guy C. Northrop

A conservative estimate of the quantity of sulfur jointing compounds used during the past half century is approximately 150,000,000 lb. As sulfur jointing compounds are employed in place of calking lead and are so much lighter in weight, the saving in material can be conservatively calculated to represent about $40,000,000.

Consider also the further saving in labor, as represented by the elimination of calking. Freight charges are reduced more than one-half, and millions of gallons of water are saved annually due to the tightness of compound joints. If these savings could be estimated, the author is firmly convinced they would total at least an additional $40,000,000.

The invitation to take part in this panel discussion noted that some of the users of sulfur jointing compounds have encountered such problems as the disintegration of the jointing material, the corrosion of pipe at the sulfur surface and the breaking of pipe bells. It was further noted that these users wish to be guided in their handling of sulfur compounds so that the best results can be obtained. The author and other manufacturers of joint compounds taking part in this discussion were requested to provide such guidance or to suggest a course of investigation to be followed.

Disintegration of Material

For more than twenty years the author has been associated with the joint compound industry and during that time has received only one report or communication referring to the disintegration of jointing materials. This occurred during the war, and the report came from an army proving ground. A field representative who was immediately dispatched to the area discovered that the pipeline was buried with less than 2 ft. of cover and was installed in the immediate vicinity of some very large guns which were being fired frequently. In an attempt at sterilization, an exceedingly strong dosage of copper sulfate had been introduced into the line before putting it into general use. This dosage was of sufficient strength to affect the hydrants, completely disintegrating the stuffing box packing and corroding the working parts.

About one month after the line was completed, a number of compound joints showed signs of disintegration. These joints were adjacent to the gun positions and also to the place where the copper sulfate was fed into the line. The soil seemed to be uniform over the entire line but only about one-third of the pipe joints showed any trace of disintegration.

Samples of the soil and compound were given to a specialist in microbiology for analysis and experiments. Although it was found that the soil samples contained sulfur bacteria, there was no evidence to indicate that their presence was the cause of the trouble.

After carefully reviewing all available data on research carried on in the New Jersey Agricultural Experiment Station at Rutgers University (*see* p. 729, this issue) it is the author's conclusion that no evidence exists to support the suspicion that the disintegration of sulfur compound joints is due to sulfur bacteria. During these experiments various germicides were studied and certain ones were found to be relatively toxic to the sulfur bacteria. Northrop & Co. selected one of these germicides after tests were conducted to determine whether this material would mix uniformly with sulfur and other compound minerals. Further tests were made in an effort to determine whether the addition of this germicide would change the characteristics of the present compound.

On March 1, 1948, Northrop & Co. mailed a new booklet to all customers, and many prospects, which contains the statement: "Germicides have been recently developed to prevent action of sulfur bacteria on sulfur joint compounds and we will gladly furnish Bond-O containing such a germicide upon request."

In the nine weeks since these booklets were mailed, not a single inquiry has been received from any user referring to a germicide.

Pipe Corrosion at Sulfur Surface

There is no evidence that the problem of the corrosion of pipe at the sulfur surface is widespread or that sulfur jointing compounds, as such, are responsible for the corrosion of cast-iron water pipe.

On November 15, 1945, Northrop & Co. began an accelerated test to determine whether Bond-O joints would cause pitting or corrosion of pipe at the compound surface. A test section, consisting of ten 4-ft. lengths of 6-in. pipe, was set up aboveground and all joints poured with Bond-O. This line has been filled and emptied many times and has been constantly exposed to atmosphere, rain and snow. For three winter seasons it was left empty on the ground, completely buried under snow. The line has carried pressure for about fifteen months out of thirty and has been left dry and open to the atmosphere for the remaining fifteen months. Tests have been made upon many occasions, at pressures from 250 to 550 psi. Joints were cut out and inspected after six, twenty and thirty months had elapsed, and no sign of corrosion or pitting of the pipe is in evidence.

Breaking of Pipe Bells

The breaking of pipe bells jointed with a sulfur compound must be extremely rare, for the author has no intimate knowledge of places where this problem has been encountered. An interesting experiment was recently started by Northrop & Co. which consisted of pouring Bond-O joint compound into thin glass test tubes approximately $\frac{1}{2}$ in. in diameter, the thickness of the average joint. After cutting off the closed ends, the test tubes were placed in a pan of water and, in order to accelerate any action, one end of each tube was left exposed to the atmosphere. Each day the tube ends were reversed in the pan and fresh water was added. After three months of this treatment the surface of the compound shows a slight discoloration but there is no evidence of expansion and the glass tubes are intact.

In conclusion, and for the future guidance of sulfur compound users, it is well to remember that there are thousands of miles of cast-iron pipe

jointed with sulfur compounds, representing a saving of millions of dollars. These compounds are giving excellent service and compare favorably with other water works materials which are manufactured by various companies and sold in competition.

The manufacturers of sulfur compounds have a definite responsibility to furnish material which will function properly at all times and last indefinitely. This they can do. Should trouble develop or problems arise, the manufacturer of the particular compound causing the difficulty must accept this responsibility and make such changes in his methods or ingredients as may be indicated.

W. Victor Weir

The purpose of this discussion is to evaluate the properties of sulfur jointing compounds, singly or severally, to find whether such compounds are suitable materials for making bell-and-spigot water main joints. The statements made by the author must necessarily be based upon personal experiences and upon the authentically reported experiences of others.

Some day an inventor may come forth with a machine and a process by which the water main will be made on the job and extruded as a permanent, flexible tube of any desired length. There will be just two joints, one at the beginning and one at the end of the job. Until that time arrives, however, it will be necessary to make, and probably repair, many joints between innumerable short lengths of water pipe.

Water mains constructed today are compromises. An attempt is made, with the money available, to install pipes which will be as permanent as possible. The pipes can be handled only in moderately long lengths and must be jointed. Because the pipes themselves are not very flexible, the flexibility must be built into the joints. Pipes often have to be lowered, preferably with the pressure on, and the joints must give and still hold.

There seems to be no way of eliminating joints. The problem is to get good joints at a reasonable price. For many years sulfur compounds have been used as the jointing material to connect thousands of miles of bell-and-spigot cast-iron pipe. In several respects sulfur compounds are superior when compared with other available material and other types of joints. The price is low; joints can be made with a minimum of labor and are tight after a short take-up period; the material will "self-seal" if it is cracked by the movement of the pipes after they have been installed; and the compound is readily obtainable.

The wide acceptance of sulfur-compound jointing material is borne out by the number of brands advertised in the A.W.W.A. Journal. Sulfur compounds are also accepted as a jointing material for private underground fire protection mains.

Questions have been raised about the service life of sulfur compounds. Statements have been made regarding unsatisfactory experiences with one or more brands of this material. Failures have been reported and have been attributed to various factors, such as bacterial attack upon the sulfur, the presence of certain ingredients in one or more brands, and poor workmanship and improper handling.

Although the failures are real, their actual causes are obscure. Some investigators have ascribed very definite

causes to certain reported failures, but others indicate that circumstantial evidence has been given too much credence, and the failures may not have been due to the causes assumed.

The author agrees that more information regarding sulfur compounds is desirable and that careful investigation of old compound joints is needed to predict more accurately the useful service life which may be expected of these materials. It is necessary to know the effects of various soil conditions upon the life of such joints, in order to determine when and when not to use them. It should be ascertained whether electric current flow in a main will affect the jointing material or the pipe metal at the joint; whether galvanic corrosion may result from the dissimilarity of the elements iron and sulfur; and whether the protective coating on the pipe has any effect on the life of the sulfur jointing compound.

Several epidemics of failures of sulfur-compound joints have been reported, so severe that the utilities involved have refused to use any more. Sometimes the failures occurred after several years of service, and after a considerable quantity of the material had been used. With the present-day knowledge of research technique, it should not be impossible for a compound manufacturer to state that his material is suitable or unsuitable, depending upon soil conditions or other controlling factors.

St. Louis County Experience

The author is personally very much interested in whether or not sulfur-compound joints will last as long as the cast-iron pipes they join. St. Louis County has approximately 660 miles of cast-iron pipe with such joints, installed in the last 23 years. At the end of 1948 it is hoped to have over 700 miles laid with sulfur-compound joints.

The St. Louis County Water Co. is aware that sulfur joints have failed in other installations. Some have failed in St. Louis County, but not in large numbers. Numerous joints have been examined for evidence of present or future serious trouble, but nothing has been found to cause alarm or to justify abandoning the use of sulfur-compound joints for a more expensive type.

A total of 113 miles of sulfur-compound-jointed pipe has been in the ground for 20–23 years and 279 miles for fifteen years or more. Approximately 50,000 of these compound joints are more than twenty years old, and 125,000 joints are more than 15 years old. The 660 miles of compound-jointed pipe contains a total of about 300,000 compound joints. If sulfur compound is unsuitable, definite evidence of the fact should have been noted by this time.

In the last six months it has been necessary to repair 27 sulfur-compound joints. Bell-joint clamps were used on 18 joints. Three joints were cut out and repoured. Tapping stopped leaks in the remainder. There was no evidence at all of attack on or corrosion of the pipe metal.

In the same six-month period 14 lead joints had to be recalked. This is 52 per cent of the number of compound joints worked on, whereas the 220 miles of lead-jointed pipe amounts to 33 per cent of the mileage of sulfur-compound-jointed pipe.

The experience in St. Louis County has not been compared in detail with that of other utilities, although it is

known that some utilities have had a much higher percentage of joint failures. Others may have had less.

The author is unable to suggest what to consider as a satisfactory or unsatisfactory joint mortality rate or why joints will fail in one environment when they will work satisfactorily in very similar circumstances.

To summarize, experience indicates that sulfur compounds are a suitable jointing material in the situation in St. Louis County. Although jointing compound failures have occurred, their number has not been serious. It is not known whether these failures were due to adverse environment, faulty materials or faulty workmanship. Because all the joints have been made by experienced employees, it is believed that faulty workmanship has been kept to a minimum. Since there has been evidence that part of the jointing material in most defective joints was good, while part had deteriorated in sulfur content, it appears that there has been a minimum of faulty materials. The effect of environment upon the constituents in sulfur jointing compounds, therefore, seems to be the most important factor in the joint failures experienced in St. Louis County.

Supplementing Water Supplies With Fluorine

By M. Starr Nichols

A contribution to the Journal by M. Starr Nichols, Prof. of San. Chemistry, Univ. of Wisconsin, Madison, Wis.

IN a recent article (1) Abel Wolman raises the question, "Should public water supplies be used for mass medication?" Wolman very ably discusses the various kinds of chemicals used in water treatment and arrives at the valid conclusion that "the exact physiological effects of each of these have not been worked out in laboratory detail. The mass results, however, of such use of chemicals certainly seem favorable." Wolman then goes into a discussion of the word "medication," which he chose to include as a part of his topic. Chemicals such as fluorides and iodides, normally present in some waters but not in others, are, by his definition, apparently to be classed as medicaments when added to the water, but if naturally present are not to be so classed. When the vitamin-D content of milk is increased by irradiation, one would conclude that the milk was medicated by the process. Certainly it should be so considered, if Wolman's usage is to be followed, when the amount of this vitamin is raised by the addition of concentrates. Enriched flour would fall into the same category of medicated foods.

In the author's opinion, if an accessory factor is added to a diet, either by the manufacturer or the consumer, the correct word to be used is "supplementation," or—if a still more attractive term is desired—the word "enrichment" might be borrowed from the flour manufacturers' vocabulary. Thus, since fluorides are naturally present in certain waters and perform some function in the prevention of dental caries, they are not, at least in natural waters, medicaments. These fluorides, when present in proper amounts, appear to perform part of the function formerly ascribed solely to calcium and phosphorus in the building of a sound, resistant tooth. If this is true, the addition of fluorine compounds to waters deficient in that element is simply supplementation and falls in the same category as any food supplement, whether it be a vitamin added to milk or minerals, such as iron, added to flour.

Wolman very clearly points out the advantages of natural fluoride-containing waters in the reduction of dental caries rates. He raises the question, however, whether water supplemented with fluorides will accomplish the same reduction in caries as is effected by waters containing fluorides naturally. Fluorine when naturally present in waters in a dilution of 1.0 ppm. exists as the "fluoride ion." Any fluoride added to a water in like concentration would also be present in the form of fluoride ions. The chemical identity of the fluoride whether naturally present or artificially added is unquestionable.

It is true that excessive fluorides in water can cause mottled enamel, and

some cities using such waters must reduce their fluoride content. The incidence of dental caries varies inversely with the fluoride content only up to approximately 3 ppm. As the fluoride content increases above this amount, so will tooth defects increase. Experience at Grand Rapids, Mich., Newburgh, N.Y., Sheboygan, Wis., and Evanston, Ill., have proved that fluorides can be added accurately, economically and safely.

Wolman gives a rather dark picture concerning the attitude of informed authorities on the supplementation of waters deficient in fluorides. In Madison, Wis., 103 out of 106 dentists asked the Common Council to vote that the city supplement the water by the addition of fluorides. On the medical side, 154 out of 180 physicians in that city made the same request. Madison is adding fluoride ion in the form of hydrofluoric acid.

The author can heartily agree with Wolman and the Council of Dental Therapeutics of the American Dental Assn. concerning synthetic fluoride tablets. In the author's estimation, a bottle of sodium fluoride tablets, nicely flavored like peppermint candy, is a decided hazard to children in a home. Furthermore, supplementation over a period of fifteen years in this manner would be an arduous task for parents, and such a program would not reach all children.

As to cumulative effects, a comparison of vital statistics for Green Bay, Wis. (fluoride content of water 2.3 ppm.), and Sheboygan, Wis. (fluoride content 0.05 ppm.), both cities with a population of about 40,000, showed no significant differences in death rates for the major causes of death. These include deaths from heart disease, cancer, cerebral hemorrhage, nephritis, pneumonia, diabetes, tuberculosis, influenza, appendicitis and stillbirth. Green Bay has been using this natural fluoride-bearing water for about 40 years. The comparison was made for a recent five-year period before Sheboygan began supplementing its water.

The author is in agreement with Wolman on his guiding "Principles" 3 and 4, but not on 1 and 2.* Results of "experiments" at cities now practicing fluorination will be little more conclusive than the mass of data on waters containing 1 or 1.5 ppm. of fluorides which has already been accumulated during the past half century and is now being studied. While waiting for this fragment of supplementary data, a generation of children will grow up with carious teeth and will later be wearing dentures. At that time their

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* As set forth by Wolman (1), these principles read:

Principle 1. Until the periods of controlled experimentation on water have fully elapsed and the findings on those procedures and their effect upon the exposed population have been authoritatively reviewed and assayed by competent medical, dental and public health professionals, the water works official should avoid the use of the public water supply for medication.

Principle 2. Even at that time, practices for treating the diseases of the people in ways other than through the community water supply should be thoroughly evaluated from the professional and the economic standpoints. In general, such alternative practices, inherently more specific in their nature, are to be preferred.

Principle 3. Universal application of chemicals to water for medication should be predicated upon substantial unanimity of opinion by official medical and public health agencies on the efficacy of the treatment proposed.

Principle 4. A natural prerequisite to any procedure for mass medication through the public water supply is complete concurrence between the officials of the water department and those of the health department.

teeth will be beyond any reclamation by science. Principle 2 holds out a forlorn hope that some other means of supplementing the deficient fluoride intake may be found. The addition of fluorides to flour, milk, salt or other common articles of diet has been contemplated, but no method thus far seems so safe, adequate and economical as the fluorination of water—safe, because not enough water containing 1 ppm. of fluoride could be drunk to cause the least harmful effect; adequate, because every child, regardless of social, educational or economic status, would be able to benefit without effort on the part of his parents; economical, because it costs only about 10¢ per person a year.

There are, of course, many problems presented by dental caries. The supplementation of a water supply with an element in which it is deficient is in reality a dietary matter and only a part of the entire program. It is equally important that the food intake be adequate as to quality, quantity, and calcium, phosphorus and vitamin content. Reasonable dental care will also be necessary. Scientific surveys have definitely shown that the omission of one link in this chain of protection—the proper intake of fluorides—produces conditions favorable to a rampant dental caries rate, such as is found in all cities so far surveyed which serve water deficient in fluorides.

Conclusion

The probable advantages of adding fluorides to waters low in fluoride content should be considered with the known disadvantages of failing to do so. There seems to be no valid reason why waters low in fluorides should not be supplemented to the safe level of 1.0–1.2 ppm. Pregnant women need the substance for the development of the anlage of temporary teeth in the fetus; young children need it to construct resistant temporary teeth so that malocclusion of the permanent teeth will be prevented; and finally, fluorine is necessary for the proper construction of permanent teeth for life. The supplementation of drinking waters deficient in fluorides for mass protection against dental caries is an advance in public health practice second only to the control of enteric fevers by water chlorination.

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Discussion

H. Trendley Dean

Dental Director, U.S. Public Health Service, Bethesda, Md.

M. Starr Nichols' paper on the fluorination of domestic water supplies would be interesting even if the question of nomenclature were not included. For whether the fluorination of water is called "medication" or "supplementation" is not of vital importance from the point of view of the anticipated results.

Nichols states that he agrees with Wolman's guiding Principles 3 and 4, but not with 1 and 2. The writer is inclined to concur with Wolman also in Principle 1 (*see* footnote, page 752). Acceptance of Principle 1 would not, of course, preclude communities from initiating carefully controlled fluorina-

tion studies, provided the experiments are planned in a manner which will permit the interpretation and evaluation of the subsequent results.

In fact, it would be highly desirable to have a number of additional fluorination studies in different states. These experiments should be so distributed geographically as to provide specific information relative to the optimal concentration of fluorine needed under particular climatological conditions. It is quite possible that more than 1 ppm. might be required in areas having a low mean annual temperature, such as the Dakotas, while 0.5–0.6 ppm. might suffice where climatological conditions are reversed, as in the deep South or the Southwest.

Nichols' statement concerning the chemical identity of fluorides naturally present in water and those artificially added would seem to be supported by the recent studies of McClure and his associates (1). These workers reported no essential differences between using Galesburg, Ill., domestic water (fluorine content 1.8–1.9 ppm.) and Urbana, Ill., water (fluorine content 0.3 ppm.) built up to a comparable concentration by the addition of sodium fluoride.

The accumulated knowledge at present suggests that the observed fluoride-dental caries relationship may be converted into a practical method of mass control of caries. The final direct proof, however, will be obtained when the results of the present experimental studies are completed.

As pointed out previously, however, the question of the optimal fluoride concentration for a given geographical area still requires further investigation. Additional controlled fluorination studies, properly distributed geographically, would give direct proof on such points as (1) the effectiveness of fluorine, (2) the optimal fluoride concentration for different geographical areas and (3) the possible influence, on the fluoride potency, of other chemical constituents of natural waters, insofar as these and other variables may affect the action of fluoride on the control of dental caries in a human population.

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The Sun and Precipitation

By C. G. Abbot

A paper presented on Nov. 20, 1947, at the Four States Section Meeting, Washington, D.C., by C. G. Abbot, Research Assoc., Smithsonian Institution, Washington, D.C.

"THE observation of the amount of heat the sun sends the earth," wrote S. P. Langley (1), "is among the most important and difficult in astronomical physics. It may also be termed the fundamental problem of meteorology, nearly all [of] whose phenomena would become predictable, if we knew both the original amount and kind of this heat; how it affects the constituents of the atmosphere on its passage earthward; how much of it reaches the soil; how, through the aid of the atmosphere, it maintains the surface temperature of this planet; and how, in diminished quantity and altered kind, it is finally returned to outer space."

For 45 years the Smithsonian Astrophysical Observatory has been checking solar radiation (2). The heat in the sun's rays has been measured not only at the ground, but also as it would be if the observer could be in free space at the earth's mean distance from the sun. The result obtained is called the solar constant of radiation and is expressed in the heat unit, the small calorie. The average value is 1.94 calories per square centimeter per minute, although at different times the solar radiation may be 1 per cent above or below that figure.

Instruments were invented and new methods perfected. Beginning at Washington, D.C., the work was transferred to Mt. Wilson, Calif., then to Mt. Whitney, Calif., and then across the Atlantic to Bassour, Algeria. By 1915 so much evidence had been collected that H. H. Clayton, Chief Forecaster of Argentina, was able to show in an extremely significant paper (3) that the sun's variation is a major element in weather. Theretofore observations had been sporadic; they had taken place only in the summer and autumn, and not daily. Clayton's paper was so impressive, however, that observation stations were established throughout the world to measure the sun's radiation on every favorable day.

The Smithsonian Institution now has on file (4, 5) over a quarter century of daily records of the sun's radiation as it would be if observed at mean solar distance in free space. These records show variations, seldom exceeding one per cent, in the sun's output of rays that warm the earth. But the sun's rays comprise many frequencies. There are some beyond the violet and some below the red of the spectrum that the eye cannot see at all. These rays show great dissimilarity in their changes of intensity.

Ozone and Weather

The ultraviolet rays of the sun, though feeble, are highly important and very variable. Oxygen in the form of ozone exists in the higher atmosphere,

although in a quantity so small that, if brought down to sea-level pressures, the ozone layer would be only as thick as a sheet of cardboard. But it is indispensable. This ozone layer totally extinguishes all rays from the sun shorter than 2,900 Å. If it did not, vegetation and animal life would perish. One would be burned by those extreme ultraviolet rays far more in a moment than by a whole day's exposure at the seashore.

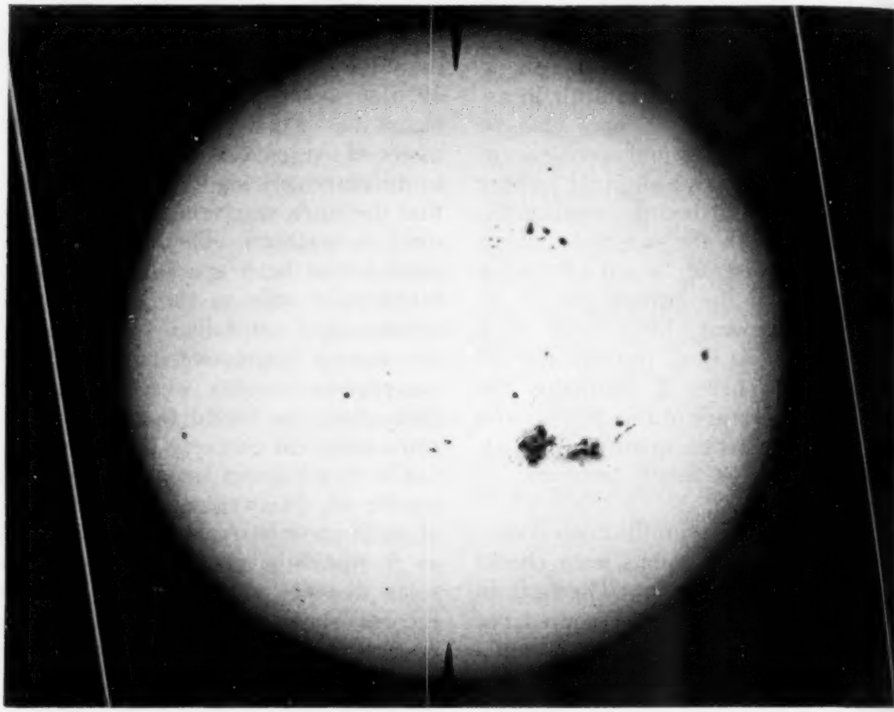

Fig. 1. Sunspots

The high-level atmospheric ozone is made from the oxygen of the air by the extreme ultraviolet sun rays, which ozone and oxygen cut off from coming to sea level. The amount of atmospheric ozone varies nearly 50 per cent from time to time. These ozone variations are believed to be caused by extreme variations of the sun rays in that unobservable region of the spectrum. From indirect evidence, physicists estimate that the sun rays in this very short wave spectral region vary by several hundred per cent (6). Smithsonian measurements cannot, of course, reach this extreme ultraviolet region, but the view that enormous percentage changes in the sun's output occur there tends to be confirmed, because about six times as great a solar variation is found in the ultraviolet rays as in the sun's heat as a whole.

Ozone is believed to be an important weather element in a way which deserves further investigation. Because the earth cools itself by radiat-

ing long-wave rays to outer space, its temperature is maintained by a balance between the heat received from the sun and the heat lost by the earth in these invisible long-wave rays. Water vapor and carbon dioxide in the air cut off most of the long-wave rays emitted by the earth's surface, so that the principal cooling surfaces of the planet are the clouds in the atmosphere. But there is a stretch of the spectrum, at about $10\,\mu$ wave length, where the earth's surface would radiate freely to outer space if it were not for an absorption band of atmospheric ozone there. This band has an average absorptive power of approximately 50 per cent (7).

There is every reason to believe that as the quantity of atmospheric ozone varies with the large changes in the sun's radiation in the extreme ultraviolet region, the absorption in this long-wave ozone band changes greatly, and thus exerts a major influence upon weather. The Smithsonian Institution is preparing to observe this infrared absorption of ozone regularly, but as yet, unfortunately, there have been no such observations.

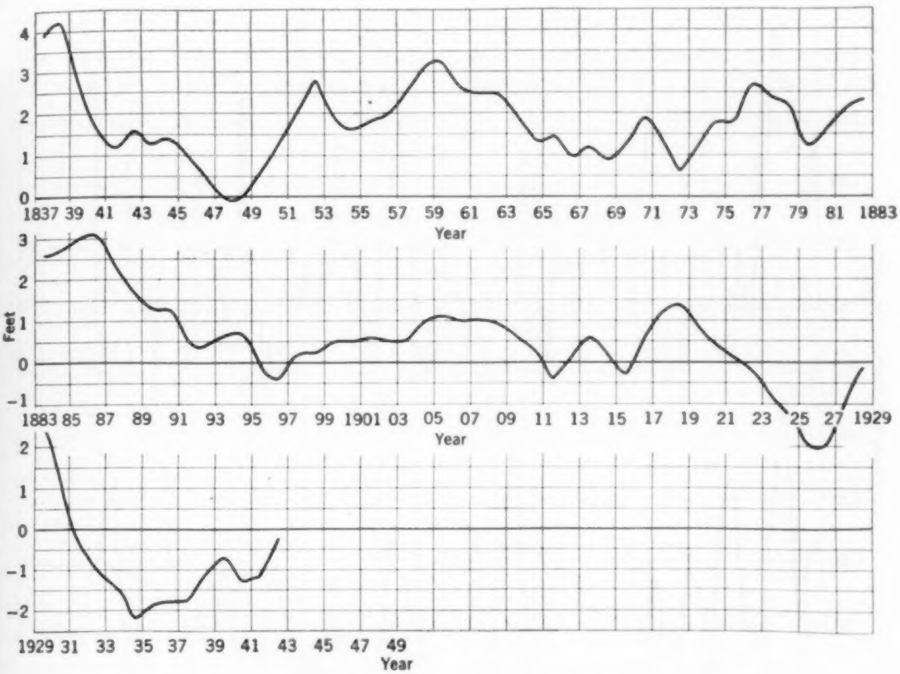

Fig. 2. Lake Huron Levels, 1837–1941

Sunspots

There is another way in which the sun may affect weather. The year 1947 has witnessed the greatest display of sunspots for nearly two centuries. (Figure 1 is a solar photograph taken March 11, 1947, at Mt. Wilson.) Indeed, perhaps never has the sunspot activity been so great.

Sunspots are whirling tornadoes in the sun, which are sometimes big enough to swallow up much more than the whole earth. Streams of matter fly produce magnetic storms that even interrupt wire communication, and give rise to displays of northern lights. There sometimes appears to be a de-

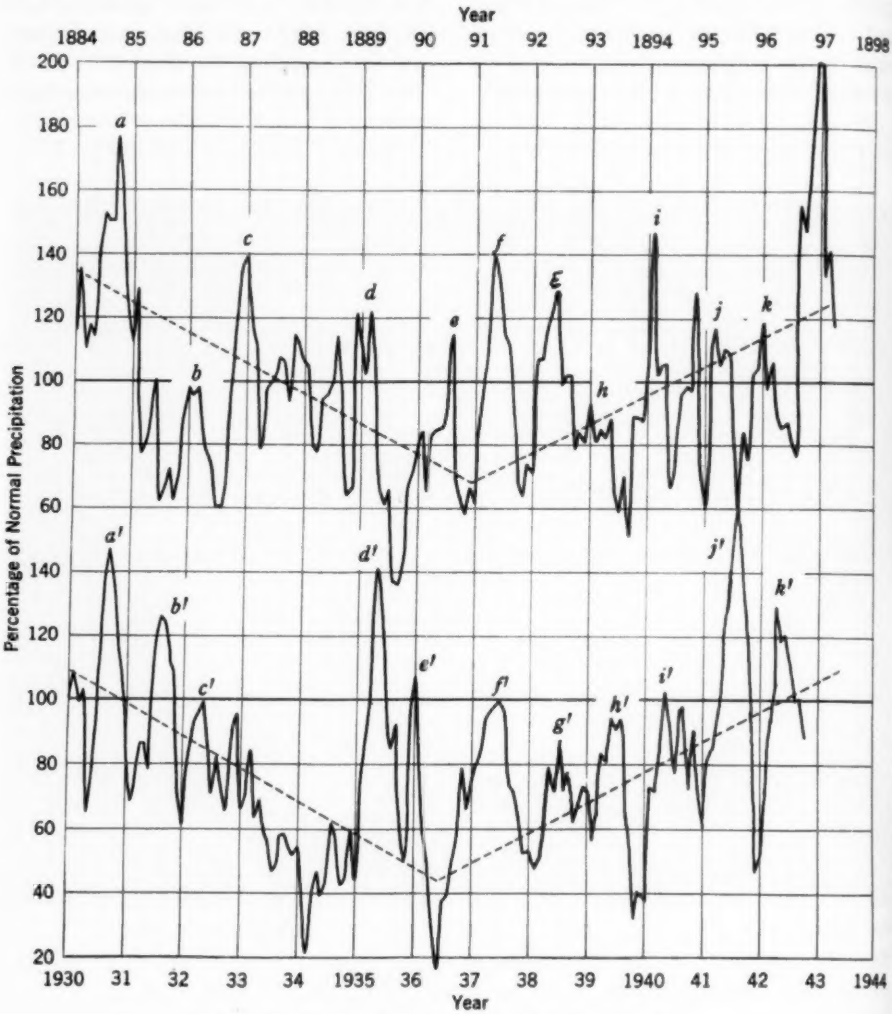

FIG. 3. Bismarck (N.D.) Precipitation Cycle

about them at millions of miles per hour, and they are strongly magnetic.

From sunspots are shot out streams of electrified particles. When these reach the earth's atmosphere in profusion, they alter radio transmission, cided effect on the sun's heat. One can suppose that a stream of these minute electric particles, 93,000,000 miles long, might very well produce some obstruction to sun rays. On March 20, 1920, an enormous sunspot

group passed directly through the center of the sun's visible disk. There was a tremendous magnetic storm, and the Smithsonian measurements showed a depression of the sun's radiation of about 2 per cent.

It is not improbable that sunspots are causing the succession of dangerous hurricanes which have lately occurred. Not all great central sunspots cause such large terrestrial disturbances. On the other hand, sometimes great magnetic storms occur when a large sunspot group is visible, but not close to the center of the sun. As has been remarked, the sunspots are perhaps more like shotguns than like rifles. They scatter their fire and thus do not have to point squarely towards the earth to hit it.

Sunspots have a rhythm in their appearance. They are numerous at intervals about eleven years apart. Between these maximums of appearance there are minimums when almost no sunspots occur for months. In the eighteenth century, indeed, many years passed without any sunspots appearing at all. Numerous investigations have attempted to determine whether the eleven-year cycle of sunspots is the cause of changes in temperature, rainfall, crop yields and market values and of social disturbances leading to revolutions and wars. The testimony is confusing, but on the whole tends to support such views (8).

Two kinds of changes in the sun, therefore, are factors in weather and precipitation: (1) the variation of the sun's output of radiation to warm the earth and (2) the variation of sunspots and their ionic bombardment of the earth.

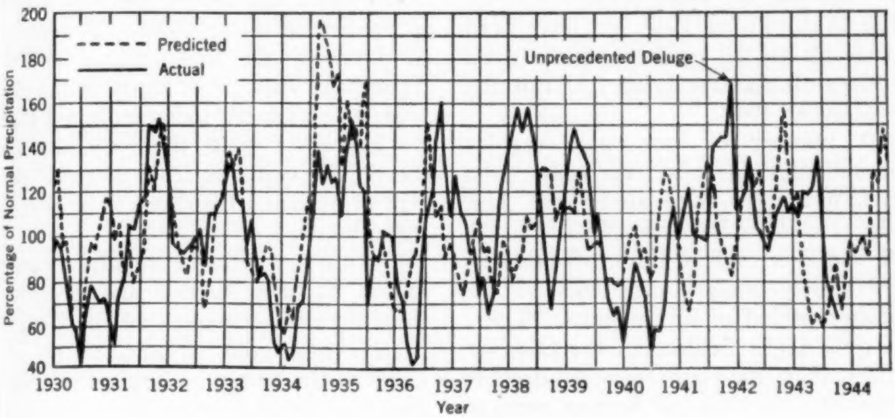

FIG. 4. Comparison of Actual and Predicted Rainfall

Periodic Solar Changes

It appears that there are many fixed periodicities of variation in the sun's output of radiation (6, 9–11). There is a regular period of 6.6456 days, recurring either four or five times every month. On the average, the change in percentage in the solar output is very small, but the associated weather effects on the earth are considerable. Changes from 2° to 20°F. in the temperature of Washington and other cities (such as St. Louis and Helena, Mont.) have been shown to be associated with this $6\frac{2}{3}$-day variation. It also

affects precipitation to an average extent of nearly 100 per cent.

Moreover, the 27-day rotation period of the sun also causes a slight average change in solar radiation. Based on this 27-day cycle the author has for some time been publishing in January a forecast for the year of dates when it is likely to rain in Washington (12). For thirteen years the average precipitation on these preferred days has been 1.5 times as great as the average on all other days. Of the first 9 months of 1947, six have been favorable to the predictions, the ratio in the author's favor being 1.17 through September 1947.

A number of long-range regular periodicities in solar variation exist (6); in months, these are: $8\frac{1}{8}$, $9\frac{3}{4}$, $11\frac{1}{4}$, $11\frac{7}{8}$, 16, $22\frac{1}{2}$, $30\frac{1}{3}$, 34, $39\frac{1}{2}$, $54\frac{1}{2}$, 68, 91 and 273. All of these periodicities are nearly integral fractions of the master period of 273 months. There is only slight evidence from observations that the half period, or 136 months, which is the famous sunspot cycle, exists as a regular periodicity in the sun's output of radiation. As previously stated, the sunspots express themselves in another way, which will be discussed below.

Long-Range Predictions

The double and quadruple of the master period of 273 months—that is, 45 and 91 years—appear to have a powerful effect on precipitation (13). Figure 2 shows that the level of Lake Huron fell 5 ft. after 1837 and again after 1929, and nearly as much after 1882. The 273-month period is also visible in the changing level of Lake Huron, but not so strongly. On this evidence the author has ventured to predict (13) that there will be rather dry years after 1952, and great droughts in the northwest after 1984 and 2020, like that which came to ruin farmers after 1929. Figure 3 shows how great a similarity occurred in the precipitation of Bismarck, N.D., at intervals of 46 years.

For some localities one can predict with a considerable measure of success by means of the master period of 273 months. This is demonstrated by the precipitation cycle of Peoria, Ill., which repeats at intervals of 23 years. Some years ago the author was asked to predict for three months, November to January, the precipitation in the Tennessee Valley. A study of the 23-year cycles for ten cities indicated that the average for the three months for the region would be from 84 to 87 per cent of normal. It proved to be within those limits.

During the late war the author estimated by this method the probable rainfall in seven regions of the United States, three years in advance, for officers of the Corps of Engineers. According to them, there was a fair percentage of success in these predictions, but the author has not personally verified the results.

A more exact method of prediction is to find the terrestrial effect of each one of the thirteen periodicities in solar variation, by a study of many years of past records. Figure 4 shows a prediction, made some years ago by this method, for the precipitation of Peoria, Ill. The average effect of each of these periodicities on the precipitation of Peoria from 1856 to 1929 was found, and these effects were then averaged to make a prediction from 1930 to 1945. As Fig. 4 shows, a farmer armed with these predictions would have had much more precise information than one who knew only the rainfall averages for many years. This

method of using periodicities works well on some stations but not on others. It seems that the complexities of the earth's surface and atmosphere mask these solar effects at many stations, or distort them too much to be unraveled in this way. The author is now engaged in trying out this method for various stations and hopes to discover why it sometimes fails.

Sunspots and Weather

Many people ask if sunspots do not cause great weather changes. Those interested should consult H. T. Stetson's recent book (7), which shows beyond question how greatly radio communication is affected by sunspots. Stetson also takes up the relations of sunspots to weather, living things, economic cycles and so on. Much statistical research has been done on the effect of the eleven-year sunspot cycle on weather elements. W. Köppen (14) found definite evidences of higher temperatures at times of minimum sunspots than at times of maximum, but the average temperature difference associated with the eleven-year cycle did not exceed 1°F. A. E. Douglas (15), whose epoch-making studies of tree rings provide a chronology for the southwestern part of the United States extending back some 3,000 years, finds that the double sunspot cycle of nearly 23 years "has persisted in Arizona for 600 years, with an interruption from 1630 to about 1850, and in some north European localities it shows for the last century and a half." Douglas also detects the 11.3-year cycle in tree rings at various intervals lasting a century or more at a time. This evidence does not give quantitative data as to variations of precipitation, but does show that it varies with the 11-year cycle. The late H. H. Clayton did an enormous amount of statistical investigation of weather (16, 17), much of which was published by the Smithsonian Institution in its *Miscellaneous Collections* from 1917 to 1946. Stetson summarizes Clayton's precipitation results thus:

> Clayton mapped the world into regions which show greater rainfall when sunspots are most numerous, and regions where rainfall is actually deficient at sunspot maxima. While the North Atlantic Ocean shows 10 per cent to 20 per cent more precipitation in years of greater sunspots, the eastern half of the United States is the region where the rainfall is actually less during maximum activity on the sun.

To see whether this statement is borne out in actuality, the rainfall for the first nine months of 1947 at Washington may be examined. Sunspots were bigger and more plentiful that year than at any time for nearly two centuries. The normal rainfall at Washington, from January to September, is 34.9 in.; the 1947 rainfall for the same period was 34.2 in. It seems pretty clear from this comparison that water engineers could hardly count with certainty on statistical averages to give forecasts for individual localities and times.

Summary

It has been demonstrated that variations of the sun's radiation and of sunspots occur. Both show periodic fluctuations. Both affect weather on the earth. The variations of solar radiation are major causes of weather changes, producing large departures from the normal in temperature and precipitation. For some stations these effects are, to some degree, predictable far in advance. For other stations, the effects are so confused by

the complexities of the atmosphere and the earth's surface as to be thus far unpredictable. Rough predictions from a 273-month cycle have shown considerable success for some stations but not for all localities. Detailed statistical forecasts for years in advance have given excellent results at some stations but are very tedious.

Sunspots are a major factor in radio communication and are closely associated with other terrestrial phenomena. They do not appear to be major weather elements, though hurricanes may be associated with them. Nevertheless their weather effects are not negligible and may be larger than is now known.

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[*Note: Some measure of confirmation of the theories advanced by C. G. Abbot was recorded by Enrique J. Montoulieu, Civil Engineer, Havana, Cuba, in a paper entitled "Forty Years of Successful Checking of Droughts in Cuba With the Sunspot Theory," presented at the 1947 meeting of the Cuban and Florida Sections. On the basis of the 9.93-year cycle, which Montoulieu had observed was dominant in Cuba, he predicted the 1938 drought a year in advance and recommended some important water supply construction in 1937 to forestall its effects. The drought arrived on schedule, but the construction had been completed and saved the day for the enterprise in which Montoulieu was engaged.*—Ed.]

Rainfall Intensities in Havana

By Luis Radelat

A paper presented on Nov. 21, 1947, at the Joint Meeting of the Cuban and Florida Sections, St. Petersburg, Fla., by Luis Radelat, Engr. in Charge, Sanitation Works, Public Health Dept., Havana, Cuba.

IN the design of water works, data on rainfall intensities for periods of time of 30 minutes or less are not as important as in sewage plant construction, but durations of one or more hours come within the time of concentration encountered in practice in small drainage areas. Spillways for dams and pipeline crossings of drainage channels are examples of situations confronting water engineers in which rainfall intensity is significant.

In Table 1 and Fig. 1 are shown the maximum rainfall intensities for 50–360 minutes in the city of Havana over a 21-year period, as recorded by the Cuban National Observatory. On the graph in Fig. 1 the intensities for the

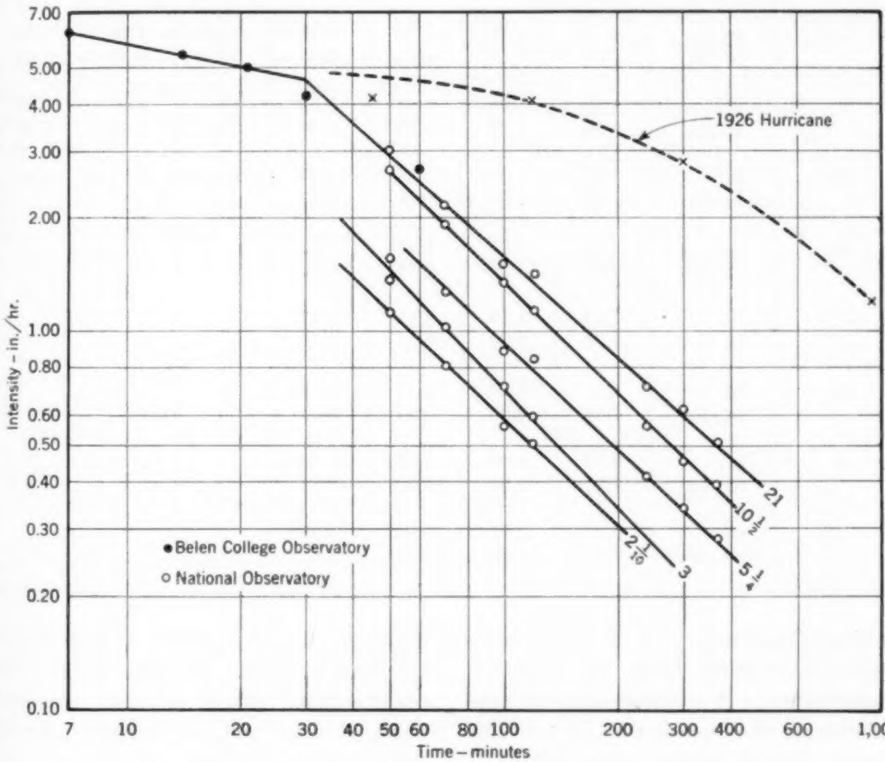

FIG. 1. Maximum Rainfall Intensities in Havana

1926 West Indian hurricane have also been plotted, to illustrate what must be anticipated at earth dam spillways. In addition, the graph includes the maximum intensities for 7–60 minutes observed during 26 years at the Belen College Observatory, located approximately two miles from the National Observatory. It is interesting to note the change in slope of the 21-year line around the 30-minute point, which is characteristic of rainfall intensity records covering a period of 20 years or more.

As is well known, thunderstorms produce the greatest intensities for short lengths of time. It appears that periods of 25–35 minutes' duration mark the limits in which Cuban tropical thunderstorms provide the highest precipitation, except in rare instances along the northern coast, when one of these storms follows closely on the track of another. The turning point

TABLE 1

Maximum Rainfall Intensities for 21-Year Period

Avg. No. of Years per Occurrence	Rainfall							
	Unit	Time—*minutes*						
		50	70	100	120	240	300	360
21	in.	2.52	2.52	2.52	2.85	2.85	3.14	3.14
	in./hr.	3.02	2.16	1.51	1.42	0.71	0.62	0.28
$10\frac{1}{2}$	in.	2.24	2.24	2.24	2.24	2.24	2.26	2.26
	in./hr.	2.69	1.92	1.34	1.12	0.56	0.45	0.39
7	in.	1.33	1.50	1.56	1.80	1.80	1.80	1.80
	in./hr.	1.60	1.28	0.93	0.90	0.45	0.36	0.30
$5\frac{1}{4}$	in.	1.30	1.48	1.48	1.69	1.69	1.69	1.70
	in./hr.	1.56	1.27	0.89	0.84	0.42	0.34	0.28
$4\frac{1}{5}$	in.	1.27	1.27	1.42	1.42	1.42		1.69
	in./hr.	1.52	1.09	0.89	0.71	0.35		
$3\frac{1}{2}$	in.	1.20	1.26	1.26	1.32			
	in./hr.	1.44	1.08	0.76	0.66			
3	in.	1.13	1.19	1.19	1.19			
	in./hr.	1.36	1.02	0.71	0.59			
$2\frac{5}{8}$	in.	1.12	1.12	1.12	1.15			
	in./hr.	1.34	0.96	0.67	0.57			
$2\frac{1}{2}$	in.	0.98	1.03	1.03	1.03			
	in./hr.	1.17	0.91	0.62	0.51			
$2\frac{1}{10}$	in.	0.94	0.94	0.94	1.02			
	in./hr.	1.13	0.80	0.56	0.51			

may then occur at the end of an hour or more. No such coincidence has been recorded at Havana, but it can be observed in the eight-year record for the inland cities of Camaguey; the change of slope took place at the 60-minute point. The intensities for periods of less than one hour are comparatively small in Havana. The West Indian hurricane of 1926 gave intensities which slope down, following the thunderstorm line (7 to 30 minutes) reasonably well for two hours.

It is the author's contention that rainfall in Cuba is caused by storms of three different types which cannot well be brought together on coordinate paper to constitute a homogeneous record. The 1926 hurricane has been excluded from the 21-year tabulation of maximum intensities, because it is felt that a separate and distinct record should be maintained for West Indian hurricanes. From the graph it can be seen that, if there is a law governing normal rainfall intensities, it is not applicable to West Indian hurricanes and to storms of the same duration as those included in the table. The latter are the high-pressure storms that sweep the United States from the Pacific to the Atlantic in late autumn and winter. West Indian hurricanes, on the other hand, are low-pressure phenomena.

Records of rainfall intensities in tropical countries covering 20 years or more are scarce; the data contained in this paper are offered as an addition to the existing information.

In closing, attention should be called to the possible effects on earth dams of the extreme intensity values of the 1926 West Indian hurricane. If this huricane had not struck Havana, the maximum rainfall intensity recorded for the period of its duration (five hours) would have been 0.62 in. per hour, or a total of 3.10 for the entire five hours. The intensity of the 1926 hurricane was 2.80 in. per hour and the total rainfall was 14.00 in. If the spillway of an earth dam had been built with an allowance of 100 per cent over the maximum observed rainfall of 3.10 in., the effects of the hurricane would have been calamitous.

Meeting the Southwestern Water Shortage

By Oswald A. Gierlich

A paper presented on April 16, 1948, at the California Section Meeting, San Jose, Calif., by Oswald A. Gierlich, City Engr. and Water Supt., Manhattan Beach, Calif.

THE southwestern portion of the United States is in the midst of the greatest drought in history, following seven years of drastic shortage of critical materials and manpower. This condition is due to the war and the postwar building boom, coupled with the unprecedented influx of population and industries into the western coastal states, especially in the southwest section of California. Many of the communities in that state have had a 100–200 per cent increase in population during this period. The city of Manhattan Beach, for example, increased in population from 7,960 in 1940 to 9,300 in 1944, with an estimated total at present of over 16,000. Many communities throughout the southwest have been faced with sudden and critical water shortages. The reasons for these shortages differ in the various areas and communities, depending upon the source of water supply and the types of water use—industrial, irrigational, domestic or a combination of these.

Although the compilation of reports from numerous communities having critical water shortages and requiring rigid restrictions is not complete, the responses of those community officials questioned provide a very fair cross section. The remainder of this paper will be devoted to summarizing the local problems encountered and the methods adopted to meet the emergencies.

San Diego, Calif.

F. A. Rhodes, City Manager, states that at the present time the water supply of San Diego is not in a serious condition and no restrictions on use are necessary. An educational program is under way, however, urging consumers to eliminate water waste. If restrictions become necessary, the first regulations imposed will limit the hours and days of irrigation, particularly of lawns and gardens. In 1941 the city passed Ordinance 2197 N.S., establishing emergency regulations for the use of water in the event of a possible shortage. The ordinance authorizes the City Manager to "declare that a water shortage emergency exists in any and/or all parts of the City of San Diego, and upon such determination, to promulgate such regulations, rules and conditions relative to the time of using water, the purpose or purposes for which it may be used, and such other necessary limitations as will, in his opinion, relieve the water shortage in any such section or sections of the City." A penalty clause provides a fine of not more than $500 or six months' imprisonment, or both.

Fresno, Calif.

Claude H. Weekes, Fresno Water Superintendent, advises that up to the present there has been no critical water shortage. The radio and press, however, are warning consumers of probable shortages in the summer of 1948 and are appealing to them to aid in reducing power consumption in accordance with the State Utilities Commission curtailment program. In the event of an emergency, Weekes proposes to permit irrigation at even-numbered houses on even days of the month and at odd-numbered houses on odd days, thereby making it easier for the consumers and water inspectors to maintain a schedule. By so doing, it is expected to decrease the daily irrigation load by 50 per cent.

Pasadena, Calif.

According to Morris S. Jones, Chief Engineer and General Manager of the Pasadena Water Dept., the only time it was necessary to resort to restricted use of water in Pasadena was in 1924. On that occasion the sprinkling of lawns and the watering of ornamental shrubbery was limited to the period between 8 A.M. and 4 P.M. This restriction, as shown by production records, did not result in a great saving of water, because evidently the usual amount of water was consumed in the hours permitted.

Vista (Calif.) Irrigation District

H. H. Yackey, Manager, Vista Irrigation Dist., San Diego County, has set forth six considerations in the rationing of water:

1. Each taxpayer should be entitled to an amount of water proportional to the taxes paid. (This requirement is included in the Vista Irrigation Dist. laws.)

2. It is essential that the amount of water allowed each consumer be determined before further plans are made.

3. Water rates should start low and rise as the quantity increases rather than the reverse.

4. The charge for meter service should be a flat rate, without free water allowance and in proportion to the size of the meter, the larger meter paying a higher meter charge.

5. Where the supply is limited by well capacity, pipeline facilities or distribution problems that are affected by peak loads in certain summer months, the water to be used in any monthly, weekly or daily period should be limited in such a way as to encourage use in the period prior to the peak demand.

6. In irrigation use, an attempt should be made to avoid peaks by scheduling the use of water by each consumer beforehand. In cities it may be necessary to require the odd-numbered houses to irrigate lawns in the mornings and the even-numbered in the afternoon, or to employ some similar method.

Fallbrook District, Calif.

George F. Yackey, General Manager and Engineer of the Fallbrook Public Utility Dist., reports that, although in the past curtailment and rationing have been resorted to, there is a general tendency for consumers to increase rather than decrease water use. A year-round educational program has been found more effective in leveling off the peak demand curve. The problem in the district is primarily seasonal and can be met by encouraging private well owners to use water from the district mains during low demand periods, thus conserving well water for use during the summer peaks. The most successful method

for curtailment, it seems, is to divide the irrigation districts into approximate halves, permitting each half to use water 3½ days a week. Emphasis is again placed on the value of a careful educational and public relations program for obtaining the best results.

In August 1946 the district distributed a communication to all consumers explaining the plan and requesting cooperation in voluntarily reducing by 20 per cent all domestic and irrigation water use. Lawns and ornamental plantings were to be irrigated only between the hours of 6 P.M. and 8 A.M., and even then as little as possible. The Winterwarm Mutual Water Co. was to cease all irrigating between 8 A.M. and noon. Users of high-pressure lines, as notified by the General Manager, were not to irrigate between the hours of noon and 5 P.M. All irrigation booster pumps taking water directly from the district lines were to be disconnected and arrangements made by the individuals concerned with the General Manager as to when the changes must be completed.

The response to this communication was so effective that, within two weeks, the restrictions were materially reduced.

Central Arizona

Under the headline "Economy of Central Arizona Threatened," a Phoenix, Ariz., newspaper (1) has stated: "Prospects for 1949 are even more alarming. Unless some unforeseeable 'miracle' replenishes the reservoirs after seven continuous years of below-normal runoff, the [district] will go into next year with empty reservoirs. This threat carries with it a 'definite possibility,' according to experts, that agricultural production in the [Salt River] valley could be cut as much as 50 per cent a year hence.

"The continued lack of water has brought a new crisis to the [Salt River Valley Water Users] Association's overburdened power system, which, O. L. (Tex) Norman, General Manager, told a Chandler audience recently, suffered a $2,000,000 loss last year."

There was no mention made of a plan for restrictions.

Ventura, Calif.

Hugh M. Wood, Ventura Water Superintendent, reports that in the recent emergency the city passed Ordinance 704 restricting the use of water, declaring an emergency and prescribing penalties for violation. The ordinance provides that: (1) No water shall be used upon lawns or annual plants, nor for the irrigation or wetting of open ground, the washing of walks, courts or lanes, nor of floor surfaces through any hose connected to the city water system. (2) The application of water, not prohibited in the ordinance, may be made to trees. (3) No water shall be used unnecessarily. (4) The use of water, except from a pail, in the washing of automobiles or other vehicles is prohibited. (5) Authority to permit the use of water for any of the purposes limited by the ordinance is delegated to the Water Superintendent. (6) The penalty for violation is $300 or three months' imprisonment, or both.

Wood comments that this ordinance has been quite effective and he has had excellent cooperation from the consumers as a whole.

It has also been necessary to limit irrigation by citrus growers to the point where crops may be seriously damaged. No analysis has been made

to determine the percentage of water saved, but it is believed the restrictions have been effective and will carry Ventura through the critical period.

Santa Barbara, Calif.

Santa Barbara, together with Ventura, has received a considerable amount of publicity during the past few months regarding the grave situation in its area. Probably no other community in the southwest is facing a summer of such drastic restrictions, primarily because of the recent failure to approve a proposed bond issue. Santa Barbara is to be complimented on the measures taken to meet the emergency and the rather comprehensive and complete procedure set up for their supervision and enforcement. In fact, it is the author's opinion that the procedure and the forms used at Santa Barbara will become a model for many other communities which are seriously affected. It appears worth while, therefore, to elaborate on the Santa Barbara ordinance and the forms employed.

On January 15, 1948, the city council adopted Ordinance 2174 restricting the use of water, determining what constitutes waste water, creating a Water Emergency Committee, providing for relief in the event of an emergency and conditions of undue hardship, and establishing penalties for violations. The ordinance defined waste as "the use of water for any purpose except minimum domestic use or for purposes essential to health and sanitation, unless said use shall have been first authorized by written permission of the Water Emergency Committee."

The prohibited uses included: lawn or garden sprinkling; wetting open ground; washing walks, courts, driveways or hard-surfaced areas; washing autos or other vehicles, commercial or private; and the use of water in ornamental or other types of fountains or pools, except for drinking purposes.

On April 30, because recent storms had improved the situation, water rationing was relaxed slightly. Residents were permitted to irrigate lawns and shrubs two hours a week, with householders on the east and west sides of town alternating. It was emphasized, however, that full rationing would be restored if the water use proved excessive.

The Water Emergency Committee consists of five persons appointed by the mayor to hear, grant or deny requests for relief claiming undue hardship or emergency. The committee's decision is conclusive.

The forms employed comprise: an emergency card placed in all hotels, motels, garages and service stations; a relief application blank; a rejection of the application; a special water use permit approving the application; and a copy of Ordinance 2174.

C. M. Pinkham, Santa Barbara Water Superintendent, states that the consumers have generally been very cooperative and that the water regulations have reduced consumption approximately 40 per cent.

Manhattan Beach, Calif.

The West Basin, which is the southwestern coastal area of Los Angeles County and extends from Long Beach to Santa Monica, includes eight incorporated cities. It contains seven major oil refineries, four large airplane factories and many other industries, all of which are heavy consumers of water. The northern and eastern sections of the basin receive a portion of their water supply from the Metropolitan Water District trunk lines. This area

has, until recent years, been entirely supplied by water pumped from the underground basin. At present the withdrawal from the basin is estimated to be three times the normal replenishment, with the result that in the past 40 years the fresh water plane in the basin has been lowered from 30–40 ft. above sea level in 1900 to 30–75 ft. below sea level in 1948. A Municipal Water District has recently been formed and negotiations are under way with the Metropolitan Water District to serve a portion of the area, primarily along the west coast. This long-continued overdraft has resulted in salt water intrusion in recent years, so that all the wells located within 1½ miles of the coast line are contaminated. Many wells are being abandoned each year and new ones are being drilled further from the saline front, which is encroaching inland at a yearly rate estimated at 500–1,000 ft. A number of wells have been rendered useless, and more will undoubtedly have to be abandoned within the next year, because of excess chlorides (from 700 to 1,000 ppm.).

In the summer of 1947 the city of Manhattan Beach received considerable publicity from the fact that during a hot spell over a weekend it was necessary to declare an emergency to eliminate the waste of water. The Water Department regulations grant official authority to the Water Superintendent to make any emergency rules or regulations to meet critical conditions. There was no special ordinance adopted, nor was one found necessary. The procedure followed was to mail cards to each consumer, which read:

Notice to Consumers—Water Restrictions. Until further notice the following regulations pertaining to use of water are in force:

During warm weather, when the temperature reaches 80°F., all unnecessary outside use of water, such as irrigation, washing of cars or trucks, etc., will not be permitted between the hours of 7 A.M. and 8 P.M. Your cooperation will assure an ample supply for normal household use. No waste of water during hours of restriction will be permitted. This situation is caused by the unprecedented growth during the past year and unavailability of water works materials.

Your cooperation will be appreciated by the Water Department.

The response was immediate and the best inspectors were the consumers themselves, who reported any waste of water during the warm periods by their neighbors. In fact, the department received many complimentary phone calls and letters, especially from those areas where the situation was most critical.

Because of the increase in demand during 1947, consideration is being given to a regulatory ordinance to restrict the hours of water use, either on a rotation basis or by prohibiting outside use between 7 A.M. and 8 P.M.

Conclusion

The foregoing summary, while exceedingly limited, is of sufficient interest to warrant a more comprehensive survey covering all areas in the states which are faced with a water shortage.

Reference

1. *Arizona Republic* (Phoenix, Ariz.), April 2, 1948.

The Proper Development of Ground Water

By E. W. Bennison

A paper presented on May 4, 1948, at the Annual Conference, Atlantic City, N.J., by E. W. Bennison, Civ. Eng., Office Engr., Edward E. Johnson, Inc., St. Paul, Minn.

THE development of ground water is a subject so broad in its definition and application that it cannot be discussed in detail in this brief paper. Therefore, only the more general phases of the subject will be taken up.

For years ground water development has been regarded as a synonym for well drilling. More recently, however, it has been realized that in the proper development of a ground water supply well drilling is only the actual construction work which may be feasible after the technical questions have been solved. Modern ground water development is therefore the practical application of technical knowledge to the exploitation of water supplies for beneficial use, free from pollution and in accordance with the best principles of ground water conservation. This requires not only a knowledge of well drilling equipment and methods, but also a rather comprehensive understanding of ground water hydrology and hydraulics, ground water chemistry, metallurgy, power generation and transmission.

Today it is known or can be ascertained where ground water comes from, how much there is of it and where it finally goes. Many users of ground water have no idea of the amount of information available in the various state and government departments whose duty it is to collect and compile such data. The fact that ground water is one of the nation's most important and valuable natural resources is beginning to be recognized by individuals, municipalities, industries and irrigation districts. This has led to a more intense study of ground water formations or aquifers; improvements in well drilling equipment, materials and methods; and last, but not least, a realization of the economic importance of ground water.

The larger users of ground water are now calling upon their technical men for exact and detailed information on the feasibility of proposed developments, before actually undertaking any drilling. No longer is it necessary to depend on well drillers, water witches or "little black boxes" for information concerning ground water, as the required data are available or can be obtained with a reasonable expenditure for preliminary investigation.

Prospecting and Testing

To establish definitely the feasibility of important ground water developments, they should be preceded by sufficient study and investigation. It is often found necessary to resort to prospecting or geophysical testing in the field, using methods that will obtain the required information quickly and with reasonable accuracy. From this preliminary work, it can be deter-

mined where the best aquifers are located, what their extent and general nature is, and whether drilled test holes should be put down or not. Test holes should always be put down before final plans are made for the construction of wells and the installation of pumping equipment. Because this will in a large measure insure the successful completion of the development, the money for testing is well spent.

To put down test holes, standard drilling equipment is used, the type depending on the nature and depth of the formations to be penetrated. As the purpose of all test holes is to obtain accurate formation data and representative samples, it is most essential that the diameter of the holes and the drilling methods used be such that the results are accurate and dependable. All test holes should be at least 4 in. in diameter, and as little water as possible should be used to obtain the samples. There are only six methods employed to put down test holes—hydraulic or rotary jetting, hollow rod, sand bucket, auger, and core. Only the first three require the use of water to remove the formation material. The hydrologist or engineer in charge must be familiar with these methods, as all sorts of formation conditions may be encountered, making it necessary to use more than one kind of drilling in order to put the holes down. Furthermore, a program of testing must be carefully planned in advance, as outlined below:

1. A sufficient number of holes should be put down to determine the area, thickness and depth of each aquifer within the sector available for the proposed development.

2. All prospect holes should be at least 2 in. in diameter and all test holes at least 4 in. in diameter.

3. All formation samples should be as nearly representative of the natural formations as possible.

4. All formation samples should be placed in containers on which depth, location and other information should be plainly marked.

5. All movements of the water table should be measured several times during the drilling, and samples of water should be obtained from each aquifer.

6. All analyses of formation and water samples should be made by persons who are experienced in such work and are qualified to interpret the hydrologic, as well as the geologic, characteristics of the samples.

On completion of such a test program, all data should be checked, correlated, studied and finally assembled in a written report with a ground water map. In actual practice, the number of test holes put down is often not nearly enough to secure the information desired, and, worse yet, every one connected with the job passes judgment on the formation samples.

It is not difficult, with a little study, to recognize the various rock formations and to know something of their origin and water-yielding ability. Unconsolidated formations such as silts, sands, gravel and glacial till can be recognized readily and analyzed easily. Samples of impervious formations such as clay, rock or shale can be identified by a microscopic examination or from their color and their reaction to acids. It is granted that this work is beyond the average well driller, but it should not be beyond the hydrologist or engineer specializing in ground water development.

Well Design and Construction

Assuming that the preliminary investigation, prospecting and testing

have been completed and the feasibility of a development determined, the next problem is that of constructing the necessary wells. In this phase, a knowledge of well drilling, including the methods and materials used in well construction, is essential. The art of drilling wells is as old as recorded history, but there was little improvement in drilling equipment, methods or materials used in this country prior to the Civil War. Thus, modern well drilling is less than one hundred years old.and, although drilling methods, materials and equipment have been improved greatly since that time, the largest advance in ground water development has been in the collection of data about ground water itself—its occurrence and movements and the yielding possibilities of water-bearing formations.

Although there are still only four methods used in constructing wells—driving, digging, hydraulic and drilling—the knowledge of well casings and screens, well development and gravel treatment has increased tremendously, so that it is now possible to construct wells of the proper type in any water-bearing formation and develop its maximum yield. As a result, many ground water developments are now made in formations that previously were considered of little or no value as water supplies.

Selection of Well Type

In the past little attention was paid to well design. No one knew the relation of yield to well diameter, well depth, screen length, percentage of open screen area or drawdown. These relationships have now been worked out, and it is also possible to determine the ground water velocities and the yielding ability of water-bearing formations. With all this information available, there is no reason to be guided by local customs, personal opinions or the recommendations of those whose interest it is to drill a hole at so much a foot. Many ground water developments have been partial failures from the day they were completed, because wells of the wrong type were used in the water-bearing formations. One of the fundamentals of good ground water development is to select the proper type of well for the aquifer and then construct it regardless of cost. After considerable study and investigation, a committee of this Association prepared what is probably the most complete and usable set of well specifications in existence (1). Only eleven different types of well construction are recognized in these specifications. For all practical purposes they are sufficient and, if used more widely, would result in better wells.

The matter of selecting the proper type of well and method of building it is not too difficult, if these principles are considered:

1. The proposed well should be constructed of materials that give the longest life under the soil, water and pumping conditions which are already present in the ground formations or which may result from the operation of the well. Because corrosion and incrustation—and, therefore, the life of the well—may be involved, this principle cannot be overlooked or neglected.

2. The proposed well should be so constructed that it will make the maximum quantity of water available for pumping with the least possible drawdown per gallon.

3. The proposed well should be so constructed that only usable water can enter it at any place and only through the openings provided for this purpose.

If these three conditions are kept in mind in selecting the proper type of well, many failures will be avoided. It is the duty of all who are responsible for choosing the type of well construction to be guided by the judgment of someone qualified to make such recommendations. Too often this responsibility is either placed on, or assumed by, the well driller or the purchaser. A mutual sharing of responsibility and the use of ordinary horse sense are far better in selecting the kind of well than is the acceptance of a special type of well using methods or materials that have not been tested by experience. Specifications are frequently prepared for the construction of wells that are not in any way adapted to the formation in which they are to be located. At times the purchasers of wells are guided entirely by the cost, which invariably means unsatisfactory wells.

Ground Water Conservation

In addition to the need for better well construction, there is another phase of ground water development that has been almost entirely overlooked in the past: the necessity for more information and better use of the ground water now available in underground reservoirs. More should be learned about the location and extent of these reservoirs, the amount of water they have in them, the rate at which they are being replenished and the rate of withdrawal. The whole subject of ground water development and use, including well construction, requires more study if these reservoirs are to be preserved and at the same time used to the limit of their safe yield.

There is no doubt about the increased demand for and use of ground water which has resulted from improvements in the construction of wells and in pumping equipment, as well as from the wider distribution of cheap electric power. The necessity for maintaining ground water supplies is obvious. The question confronting the users of ground water is: how can this be done? Undoubtedly it will take time and the combined efforts of ground water users, public officials and others who realize the irreparable economic loss that will be sustained unless protective measures are adopted at the proper moment. Ground water supplies are similar to other water supplies in that no one is unduly alarmed until there is a failure or shortage, and then there is an instant demand that something be done. Most users of ground water are under the impression that ground water supplies are inexhaustible. They are little concerned about such things as proper use and conservation, because their principal desire is for unlimited use.

The quantity of water in the nation's ground water reservoirs greatly exceeds the capacity of all of the surface reservoirs, both natural and artificial. There is sufficient ground water to supply every foreseeable demand, but it is essential to take inventory of these supplies from time to time, and to make provision for their proper use and conservation for the generations to come.

Reference

1. Standard Specifications for Deep Wells—4A.1–1946. Am. Water Works Assn., New York (1946); Jour. A.W.W.A., **37**:913 (Sept. 1945).

Policies and Problems in Controlling Ground Water Resources

By H. T. Critchlow

A paper presented on May 4, 1948, at the Annual Conference, Atlantic City, N.J., by H. T. Critchlow, Chief Engr., Div. of Water Policy and Supply, State Dept. of Conservation, Trenton, N.J.

GROUND water is replenishable but not inexhaustible. Competition for ever increasing amounts has raised many practical problems and much controversy among those looking for more water to satisfy their needs. Water codes and laws to control its use, which have been enacted in several states, differ widely, depending on the conditions of use and the quantity available. In other states little or no control is exercised except to protect the water supply from contamination and to regulate its use for human consumption.

No attempt is made in this paper to cover the subject in a comprehensive manner. The discussion is based on practice in the eastern part of the country and particularly in the state of New Jersey, where laws controlling the use of ground waters have been in existence since 1910. It is the hope of the author that others will contribute their experience in other areas and add to the knowledge on this important subject.

Control Problems

The problems of ground water control may be discussed under three headings: interference, overdraft and pollution.

Interference at a well is caused by pumping another well or well field near by or even at some distance. Interference between private wells of equal use is not generally serious. Sometimes what appears to be interference may actually be the lowering of the ground water table because of drought conditions. The solution is usually found in deepening the well or lowering the pump. Where the English doctrine of the common law is in force, private owners of equal rights cannot collect damages from one another but must protect themselves by going deeper for water or by mutual agreement. When a public water works taking water from wells interferes with a privately owned well, the owner of the public supply is liable for damages on the theory that the ground water under private land constitutes a proprietary right; the owner has the right of use pertinent to the land, such as for household purposes, watering stock and the like. The public owner must therefore obtain the right to divert the water for public use from the land on which the wells are located. If two public supplies interfere with each other, the matter may be settled in the courts or by a state administrative agency established to

control the diversion and use of ground waters.

Overdraft results from pumping the water-bearing formation or aquifer at a rate greater than that of the flow from the intake area. This condition is reflected in the permanent and progressive lowering of the ground water level. In artesian areas, where wells originally flowed above the surface, the artesian pressure can, through use over a period of time, be permanently lowered. This brings about the cessation of flow and requires pumping to maintain the yield. Overdraft may be due to a variety of reasons, but is generally caused by a rapid increase in demand concomitant with growth in population or industrial development. In recent years overdraft in many urban areas has been accentuated by the use of ground water for air conditioning. The increasing demand for ground water for irrigation is also becoming an important factor contributing to overdraft in some regions in the East as well as in the West. In certain resort areas dependent upon ground water supplies, such as coastal cities in New Jersey, the summer requirements may be double or treble the average annual demand. This results in a seasonal lowering of the water level, which may not recover completely in the following slack season, so that there is a gradual lowering of the static water level. This has happened in the Atlantic City area in the so-called 800-ft. (Kirkwood) sand from which many of the beach hotels take their water. The first wells were drilled in 1893 and flowed 20–25 ft. above sea level. To date the water has dropped to about 85 ft. below sea level, with a pumpage increasing over the years to about 25 mgd. at the present time during the summer season.

Pollution is a serious problem in ground water control in many areas. This may be due to salt water intrusion into the water-bearing sands outcropping in tidal areas; to improper disposal of sewage near wells in rock formations containing fissures, crevices or solution channels; or to chemical wastes. Salt water intrusion is generally caused by the overpumping of wells in the vicinity of the sea coast or of tidal estuaries or marshes. Such pollution is generally serious, causing permanent salting of the water-bearing beds. The ruining of valuable ground water supplies has occurred in many places, such as the south shore of Long Island, N.Y.; Perth Amboy and Sayreville, N.J., on Raritan Bay; Pleasantville, N.J., on the mainland back of Atlantic City; Baltimore, Md.; the Gulf Coast in Texas; southern California; and other coastal states.

Another cause of contamination is the escape of salt water from gas and oil wells. This is a problem in such states as Ohio, Indiana and Texas. Oil and gas wells must be specially sealed to prevent the salt water at lower depths from entering the higher fresh-water-bearing formations.

Investigations

Accurate and reliable information on the occurrence and behavior of ground waters is essential in the study and solution of the problems of interference, overdraft and pollution. The geology and hydrology of the region must be determined before any satisfactory remedy can be found. The rapidly increasing use of ground water requires comprehensive, scientific planning for the conservation and economic development of these resources. Fortunately much work has been done along

these lines in certain areas and the results obtained should encourage similar studies in regions where ground water problems are becoming serious.

The U.S. Geological Survey began investigating the ground water resources of the country soon after its establishment in 1879. Its first report on the subject was published in 1885. Following this, extensive ground water surveys were made, chiefly in the western states. In 1903 the Div. of Hydrology was formed, which in 1908 was renamed the Div. of Ground Waters. Funds for this work were meager for many years, but in 1929, as a result of demands by the states for aid, Congress increased appropriations for ground water investigation, for use primarily in cooperation with state, county and municipal governments on a dollar-for-dollar basis. As a result, the Ground Water Div. has cooperated for about 20 years with many of the states on a coordinated program of ground water studies from year to year. Such continuity and coordination have favored the development of an effective technique in this highly specialized scientific field with its practical applications. Another result has been the selection and intensive training of capable geologists, engineers and physicists in the field.

New Jersey Studies

Increasing demands for ground water and improvements in drilling methods in the early twenties brought about the comprehensive investigation of ground water conditions in the state of New Jersey. This work began in 1923 and has continued without interruption to date. From July 1923 to June 1927 it was conducted jointly by the U.S.G.S. and the State Dept. of Conservation and Development. From July 1927 to June 1931 the work was carried on by New Jersey alone, at first by the Dept. of Conservation and Development and later by the State Water Policy Commission, to which matters pertaining to water supply were transferred by an act of the legislature in 1929. Cooperation between the U.S.G.S. and the State Water Policy Commission was resumed in 1931 and has been maintained since that time. In July 1945 the State Water Policy Commission was discontinued and its duties and powers were taken over by the Div. of Water Policy and Supply of the newly created Dept. of Conservation.

During this period of almost 26 years field investigations have been conducted in ten selected areas in New Jersey for the main purpose of determining, as far as possible, the safe yield of the water-bearing formations. These areas are: (1) East Paterson, (2) Canoe Brook, (3) Middlesex County, (4) Parlin, (5) Asbury Park, (6) Camden, (7) Southern Interior, (8) Salem County, (9) Atlantic City and (10) Newark. Seven reports have been published and others are in preparation. The first published report was on the Atlantic City area in 1928. The total funds expended to June 30, 1947, were about \$222,000. For the current fiscal year \$22,000 has been appropriated.

The field investigations include the operation of 277 water level stations and 153 water sampling stations for chloride analysis. The water level stations comprise 61 continuous recorders, 2 daily, 50 periodic (monthly) and 164 occasional (quarterly) measurements of water levels in observation wells in the ten areas under study.

Many of these wells have been drilled specially for observation in selected locations. Pumping tests are conducted to observe yield, drawdown, cone of depression, interference with neighboring wells, and other pertinent data. Logs of the geologic formations, including samples of materials, are obtained and correlated. Samples of water are collected for complete chemical analysis, especially from new wells, and thousands of samples have been taken from wells along the coast for chloride analyses to obtain advance notice on the encroachment of salt water.

Another very practical use of the results of these investigations is to assist the Water Policy and Supply Council in the administration of the laws on the control of ground waters, which will be discussed later in this paper. Space does not permit giving more details of this valuable work, but federal and state officials are convinced of its importance and the necessity for its continuation and expansion. Some attempts have been made recently to reduce the funds and authority for continuing the work on the federal level. The way in which local government officials, the engineering profession and the water works fraternity have rallied to the support of the cooperative program of the U.S.G.S. is most encouraging and demonstrates their interest in this program. However, no one should be lulled into a belief that the danger to the program is past.

Control Policies

The increased use of ground water has resulted from many factors. Radical improvements in the construction of water wells and in pumping machinery, as well as the development of methods of treatment of ground water to soften it and to remove iron and other objectionable minerals which may be present, have done their part in improving the quantity and quality. The demand for additional supplies in war and other emergencies has added considerable impetus. The result has been a situation which threatens the depletion of these valuable ground water resources and their possible contamination and loss by salt water intrusion. Under the pressure of growing demand, the common law right adopted in some states—that the surface proprietor has a complete and unlimited property right in all subsurface waters obtainable through wells driven on his land—has led to interference, damage and endless litigation. Even in the absence of statutory enactments, this common law right of unlimited use was modified, and a so-called American doctrine of reasonable use was adopted by some courts. This doctrine declares that ground water is not a fixed mineral always in place under the soil but moves about; that, therefore, all surface proprietors have a common or joint interest in ground water resources; and that each proprietor may be limited in his use in relation to the use of other proprietors. Now a different and further interest in ground waters has arisen—the interest of the general public in protecting and controlling the water resources of an area, such as a city or a state, to prevent exhaustion.

Statutes have thus been passed in several states to regulate diversion by private owners and the public water supply systems, and to protect all against wasteful use. Such statutes fall within the exercise of the police power, and where they have been reasonably adopted for the sake of fairness and equity and to prevent the waste of a natural resource, the statutes have been upheld.

New Jersey Laws

In 1907 a law (Chapter 252) was enacted establishing a State Water Supply Commission to regulate the diversion of surface waters for public and potable use. This included the taking of water for a new supply or an additional source for an existing supply. In 1910 a supplement was enacted (Chapter 304) extending the jurisdiction over diversions for public and potable use to include well, subsurface and percolating waters. These laws have been revised and combined in Revised Statutes 1937, Title 58, Chapter 1. This statute requires all parties supplying or proposing to supply water to the inhabitants of any municipal corporation or other civil division of the state, or proposing to condemn lands for such water supply use, to make application to and obtain the approval of the State Dept. of Conservation for the project. Public hearings are held, after which the department shall determine: (1) whether the plans proposed are justified by public necessity; (2) whether they provide for the proper and safe construction of all works connected therewith; (3) whether they provide for the protection of the supply and the watershed from contamination or provide for the proper filtration of such supply; (4) whether the reduction of the dry-season flow of any stream will occur to an extent likely to produce unsanitary conditions or otherwise injure public or private interests; and (5) whether the plans are just and equitable to the other municipalities and civil divisions of the state affected thereby, and to the inhabitants thereof, particular consideration being given to their present and future necessities for sources of water supply.

The department may issue a permit to carry out the plans as approved. Upon the completion of the construction an inspection is made and, if the requirements are met, an approval of the works for permanent operation is issued. The diversion permit fixes the amount of water that may be taken from the approved source and a time limit after which it may be renewed.

Under the statutes, 665 decisions have been rendered. The decisions are subject to review as to reasonableness, legality and form, and several have been brought before the courts, in nearly all cases the decisions being sustained. No part of the statutes has been declared unconstitutional. It is believed that the decisions have been fair and equitable and in the public interest.

Control of Private Supplies

For 40 years of operation of the statutes on the control of waters for public and potable use in New Jersey, there was no state control over private wells for industrial, commercial or other private use. The public supplies were thus subject to unrestricted interference by private wells that might be constructed and operated within their sphere of influence. For ten or more years relief was sought through legislation. Objections were raised by the owners of large wells using water in industry, railroads, hotels, and other businesses.

Finally, in 1947, a law (Chapter 375) was enacted giving authority to the State Dept. of Conservation to regulate the diversion of subsurface and percolating waters of the state for domestic, industrial and other uses. The law, which supplements Title 58, Chapter 1 (previously discussed), became

effective July 2, 1947. Nine applications have been received. The law provides:

1. The Department of Conservation shall delineate from time to time such areas of the State where diversion of subsurface and percolating waters exceeds or threatens to exceed, or otherwise threatens or impairs, the natural replenishment of such waters.

2. In areas so delineated no such waters shall hereafter be diverted in excess of 100,000 gpd. for any purpose without obtaining a permit. Such permit may be refused or, if granted, may include such stipulations as may be necessary to conserve such waters of the State and prevent their exhaustion.

3. Any refusal to grant a permit shall be subject to review by the Supreme Court, both as to question of law and fact.

4. Any person, corporation or agency diverting in excess of 100,000 gpd. from such sources shall have the privilege of continuing to take from the same source the quantity of water which is the rated capacity of the equipment at that time used for such water diversion.

Review of State Legislation

A review of the laws of several other states in which the control of ground waters is in operation or is being considered has been made, so far as the laws were available to the author. While it has been impossible to analyze these in detail, there is set forth in the appendix to this paper a brief summary which, it is hoped, will be of interest to the members of the Association and to others concerned.

Those looking for further suggestions to aid them in drafting ground water legislation should give careful consideration to A. P. Black's excellent article on "Basic Concepts in Ground Water Law" (1).

Conclusion

The importance and necessity of maintaining a ground water supply to assure a safe sustaining yield cannot be overemphasized. The conservation of ground water by legislation began in 1905 in the state of New York through the control of the acquisition of lands for new or additional sources of water supply by municipal corporations or other civil divisions of the state. Additional legislation followed in New York, and other states took up the conservation program, thus establishing permanently the policy of regulating by law the use of these important water resources.

Some states which have passed laws recently are concerned about their constitutionality because of their effect on the common law doctrine of proprietary rights. Courts are modifying their rulings, however, to accord with increased knowledge and are applying the doctrine of equitable apportionment which represents the trend in practice not only for ground water but also for surface water developments.

The demands on this source of water supply for industrial, municipal, agricultural and domestic purposes are growing out of all proportion to the increase in population. The enlarged demand has been due principally to improvements in methods of well construction, deep well pumping equipment, efficiency of pumps and motors and lower power rates. The rapid growth in the use of air-conditioning equipment in many cities is increasing the draft on wells and overloading drainage systems. This situation is bringing about the passage of laws and regulations to require the conservation of ground water by recirculating it

through cooling devices or returning it to the ground through recharge wells. In western Long Island, N.Y., alone, there are said to be over 250 recharge wells operating satisfactorily, and about 15 others in the rest of the country.

The artificial recharge of ground waters is being practiced in many localities. In New Jersey a sizable industrial well water user obtains a dependable supply of 15–20 mgd. from a large artificial lake constructed for that purpose. In California artificial recharge by spreading is practiced to a considerable extent.

The need for more scientific knowledge about the occurrence and movement of ground waters is vital to a satisfactory solution of safe yield, interference, contamination and other problems. The program inaugurated by the U.S.G.S. in cooperation with the states and other local agencies has been of great help in the economic development of ground water resources. The A.W.W.A. and its individual members should continue to support this program and enlarge it as much as funds will permit. Research is the foundation of technical progress and pays large dividends.

Improvement in existing laws is desirable and should be considered by the Association as a worth-while project. It will need the assistance of lawyers familiar with water laws as well as water works officials familiar with the administration of such laws.

Acknowledgments

The author acknowledges with appreciation the help of many public officials and others who have furnished information about the water laws in their states; also special mention should be made of the valued assistance of H. C. Barksdale, Dist. Engr., U.S.G.S., who has been in charge of ground water work in New Jersey since 1927.

Reference

1. Black, A. P. Basic Concepts in Ground Water Law. Jour. A.W.W.A., **39**: 989 (Oct. 1947).

APPENDIX

State Ground Water Laws, 1948

Arizona. The State Land Commissioner (Chapter 5, House Bill No. 2, approved April 1, 1948) has authority to regulate the use of ground water—primarily for irrigation—in excess of 100 gpm., in such critical ground water areas as may be established within the state. Certain uses of ground water—including domestic, stock watering, domestic water utility, industrial or transportation purposes—are exempt. The act was passed without an emergency clause and does not become effective until 90 days after receiving the Governor's approval. It is known as the Ground Water Code of 1948.

Indiana. Under Chapter 154, Laws of 1947, the Dept. of Conservation regulates the removal of more than 200 gpm. from the ground by any means for purposes of air conditioning or cooling, unless the water is circulated through cooling towers or other devices and re-used, or is returned to the ground through recharge wells, or a permit is secured from the Dept. of Conservation. The statute does not cover any other use than those stated.

The return of the water to the ground must be approved by the State Board of Health.

Kansas. The Ground Water Act of 1945 gives the State Engineer authority to deny or limit the development of additional wells in areas of heavy pumping. All appropriations of water must be for beneficial use. The right to take water shall terminate when it ceases to be used for a beneficial purpose for three years or more. Appropriations shall not constitute absolute ownership of water but shall remain subject to the principle of beneficial use. The law gives precedence to different uses in the following order: domestic, municipal, irrigation, industrial, recreational and water power.

Maryland. The Water Resources Law of 1933 gives the Dept. of Geology, Mines and Water Resources authority to regulate the use of any waters of the state, whether surface or underground; written permits are granted upon application submitted prior to use, and after a hearing. An exception is made for the use of water for domestic and farming purposes and for its use as an approved municipal water supply. The law requires that well drillers be licensed and that permits be obtained for well drilling.

Minnesota. The Commissioner of Conservation (Chapter 142, Laws of 1947, Section 3, Subdivision 1; and Section 5) has general authority to regulate the use of all waters of the state, both surface and underground, for the best interests of the state, and to issue permits for beneficial use.

Montana. Chapter 218, Laws of 1947, provides for the conservation of underground waters and for the casing and capping of artesian wells (defined as those flowing naturally from the top of the ground) and prohibits waste therefrom. The law is administered by the State Engineer and contains a penalty clause.

New Jersey. See above, pp. 779–780.

New Mexico. The Ground Water Law (Chapter 151, Laws of 1938) gives the State Engineer authority to control ground water—in certain instances concurrently with the authority of artesian conservancy districts. "The waters of underground streams, channels, artesian basins, reservoirs, or lakes having reasonably established boundaries are hereby declared to be public waters and to belong to the public and to be subject to appropriation for beneficial use." Applications are advertised for three weeks and are granted in whole or in part by the State Engineer if there are no objections and unappropriated water is available. Should there be any objections, a hearing is held, after which a decision is reached. Owners of water rights at the time of the passage of the law were required to file statements of beneficial use in order to establish their rights.

New York. The Water Power and Control Commission (Section 522 of the Conservation Law) has authority to approve plans and issue permits for new or additional public water supplies. Chapter 563, Laws of 1933, added the Long Island sections of the Conservation Law, giving the commission jurisdiction over all Long Island wells exceeding in capacity 100,000 gpd. Chapter 338, Laws of 1935, added Section 521–b requiring the licensing of all well drillers operating on Long Island.

North Dakota. Chapter 17, Laws of 1921, gives the State Geologist general supervision over the waters of

North Dakota and advisory authority on the practicability of measures affecting its underground waters. The drilling and control of artesian wells and the prevention of waste from them are regulated by the State Geologist, the State Engineer and the Superintendent of Schools of any county in which the wells are located. The State Geologist is charged with enforcing the law, which contains a penalty clause.

Ohio. Ohio has no specific ground water law, but the State Water Board has authority to promulgate regulations, after appropriate publicity and hearings, which have the effect of law. It is believed that this authority could be used to regulate the diversion of ground water in areas where the supply is known to be limited.

Oregon. The State Engineer (Sections 116-449 to 116-451, Compiled Laws, Annotated 1940) has authority to regulate the use of ground waters east of the summit of the Cascade Mountains for beneficial use.

Pennsylvania. The Water and Power Resources Board (Act No. 365, Laws of 1939) has authority over the allocation of surface waters for public water supply use. Legislation relative to the control of ground waters is being prepared for presentation to the 1949 Legislature.

Rhode Island. A survey of the ground water resources of Rhode Island is being made by the U.S. Geological Survey, which may lead to legislation controlling their use.

South Dakota. The State Engineer (Chapter 61.04 to 61.07, South Dakota Code of 1939) has authority to regulate the construction and use of artesian wells and to prevent waste.

Utah. The State Engineer (Utah Code Annotated 1943, Title 100, Chapter 2) has general supervision of the waters of Utah, both surface and underground, to secure equitable and fair apportionment and distribution for some beneficial use. Appropriation is made on application and certificates are issued in accordance with detailed rules and regulations as set forth in Chapter 3. In addition, permits must be obtained for drilling wells, and well drillers must be licensed. Under 100–5–1 the State Engineer has authority, on petition of not less than one-third of the users of underground waters in any area, to determine whether the supply is adequate for the existing claims, and, if found to be inadequate, he must divide the waters among the several claimants entitled to them, in accordance with the rights of each.

Washington. The State Supervisor of Hydraulics has authority to administer the Surface Water Code (Chapter 117, Laws of 1917) and also the Ground Water Code (Chapter 263, Laws of 1945), a supplement to the former. The Ground Water Code exempts from control the withdrawal of water for any purpose, when the quantity is less than 5,000 gpd. It provides a method by which ground water in excess of this amount can be legally appropriated; provides for the establishment of ground water areas and depth zones; and also provides for the control of flow from artesian wells.

Wisconsin. The Well Construction Code (Chapter 162) requires permits for the construction of wells in accordance with specific regulations which are considered a model. Applications for wells diverting in excess of 100,000 gpd. may be denied or approved provisionally, if likely to interfere with a public water supply. A cooperative study of the ground water resources of Wisconsin is being made by the State Geologist and the U.S.G.S.

Investigating Water Pollution in California

By Roy O. Van Meter

A paper presented on May 4, 1948, at the Annual Conference, Atlantic City, N.J., by Roy O. Van Meter, San. Engr., Dept. of Water and Power, Los Angeles.

INSTEAD of practicing water conservation, the people of California have developed a complete disregard for the water economies that must be practiced in order to insure future prosperity. Billions of gallons of salvageable industrial waste waters, domestic sewage and storm waters are being discharged into the ocean through lined river and stream channels, storm drains and sewers. Other billions of gallons of life-giving waters are being polluted with industrial wastes containing oils, brines, salts, heavy metals and other such contaminants. Too often towns and industries are being permitted to discharge their sewage and industrial wastes into streams and rivers and into the underground water supplies of the state. These wastes have frequently polluted the ground water supplies beyond redemption.

The water pollution problem in California has been growing in intensity for many years, but its seriousness is only now beginning to be understood. Water works operators received a real jolt in 1945 when thirteen domestic water wells located in the Montebello district were polluted with phenolic waste. It was then that water works officials in the state first awakened to the realization that they would have to face the facts of life and not put off any longer the inauguration of a water conservation program.

In the spring of 1946, at a meeting of the Southern Regional Group of the Operators and Managers Div., California Section, A.W.W.A., a round table discussion of the industrial waste disposal problem was held. Engineers and operators brought to light many instances of the pollution of water supplies, confirming the fact that the problem was not local in nature but common throughout the state. The findings of this group were brought to the attention of the members of the Executive Committee of the California Section, and they, alarmed at the rapid increase in water pollution, joined with other water works operators and groups in an appeal to the Governor of California and other state officials for remedial legislation and relief. As a result, several new laws for the safeguarding of water supplies were proposed for passage by the state legislature at its 1947 session.

Fact-finding Committee

Because some of these proposed laws conflicted with one another, it was thought desirable that they be consolidated into simplified bills which would provide effective legislation based on the needs of the entire state. To accomplish this purpose, the State Assembly passed an enabling act, H.R. 27, providing for a legislative fact-finding committee. This committee

under the chairmanship of Randal F. Dickey, Assemblyman of Alameda, Calif., was required to make an investigation of the water pollution problem in California and, after completing the survey, to prepare legislation for presentation at the 1949 session of the legislature. The act allotted $100,000 to defray the expense of making the survey. The committee hired investigators who are ably conducting an intensive investigation into the pollution of ground, surface and coastal waters. In addition, the committee has solicited the aid of water works operators, public officials, chambers of commerce, service clubs and associations, industrial groups and all others who have an interest in the problem.

The Executive Committee of the California Section offered its assistance, recognizing that the fact-finding committee must have a complete inventory, in the shortest possible time, of all known cases of water pollution throughout the state. H. Arthur Price, Chairman of the California Section, with the approval of the Executive Committee, assigned the problem to the Committee on Water Pollution and Industrial Waste, of which the author is chairman. The assignment was actually divided into three specific problems or objectives: (1) to accumulate data and submit a report on the pollution of underground waters caused by sewage and industrial wastes in California; (2) to cooperate with the state legislature's fact-finding committee; and (3) to prepare for the consideration of the Executive Committee of the California Section recommendations on the acceptability of waste waters for underground basins.

To carry out these objectives three subcommittees have been provided for: (1) the *Water Pollution Surveys Committee,* which has the responsibility of surveying every square mile (a total of 158,693) in the state to determine the extent of the water pollution problem, investigate individual incidents of water pollution and provide a report covering the details of each incident; (2) the *Standards Committee,* which has the responsibility of determining limiting standards to be used in deciding the acceptability of industrial waste for disposal on critical watersheds; and (3) the *Legislative Committee,* which has the responsibility of preparing proposed legislation for submission to the state legislature's fact-finding committee.

Water Pollution Surveys

The Water Pollution Surveys Committee, in order to provide a complete coverage, has subdivided the state into seven districts, each including within its boundaries one of the seven great water basins of the state. A chairman has been appointed to take charge of the survey in each district.

The great basin chairmen will further partition the basins assigned to them into political, geographic or geologic subdivisions and appoint group chairmen. The latter will contact water departments, water companies and officials of communities or industrial plants within their areas who may have knowledge of the water pollution problems, and will suggest to them that they gather information on water pollution, forwarding such data directly to the legislature's committee and to the author.

The state legislature's fact-finding committee has held public meetings at Oakland, Los Angeles, Fresno, Sacramento and San Francisco, in addition to innumerable private meetings. The testimony given at the State Assembly

hearings and the accumulated findings of investigators thus far have verified the fact that water pollution is common all over the state, that the problem is of a serious nature and that effective controls must be established to safeguard the state's water resources. The committee will complete its investigation during the latter part of the summer of 1948, and remedial regulations and laws will then be framed. A rough draft of the proposed legislation will be forwarded to industrial, water works and other officials—both public and private—throughout the state, for their consideration and constructive criticism. After all the interested parties have been given an opportunity to suggest amendments or to register their opposition, criticism or approval, and after all the differences have been resolved, a final draft will be prepared for presentation to the legislature during the 1949 session.

Thus, a century after the "Gold Rush," the citizens of California are preparing for another 100 years of growth and prosperity by insuring that water, the most valuable natural resource, is maintained free of man-made contamination and conserved in adequate quantities for posterity.

The Missouri Basin Program and Municipal Water Supplies

By S. J. Ware

A paper presented on April 10, 1948, at the Montana Section Meeting, Livingston, Mont., by S. J. Ware, Reclamation Economist, Bureau of Reclamation, Billings, Mont.

WATER has, since the earliest settlement of the Missouri Basin, always been a limiting factor in the lives of the people. True, sometimes there has been too much water, which caused damaging floods. More often there has been too little: too little to water cattle, too little to support agriculture in times of drought and too little for the towns when the streams ran dry or when the water table fell so low that the wells could not produce enough to supply the inhabitants.

Ground Water

The occurrence of ground water in any particular area depends upon the underlying geologic structure. The outer crust of the earth is made up of rocks which generally are not entirely solid but have numerous openings that may contain natural gas, oil, air or water. These interstices vary greatly in size and most often—though not always—are connected, so that water may percolate from one opening to another.

The porosity of a particular structure determines the amount of water which it can hold. Porosity is measured as the percentage of the volume of rock that is occupied by interstices. The rate of movement of ground water through a porous water-bearing rock structure is determined by the degree of porosity and by the hydraulic gradient which is associated with the slope of the structure. The combination of these factors provides what is known as permeability, or the capacity to transmit water.

The quantity of water which may be removed from an aquifer or water-bearing material depends upon the above factors. When water is pumped from a well, the water table in the vicinity of the well is lowered. As the pumping continues, water will be transmitted laterally through the water-bearing material at approximately the rate that it is being pumped. The water table assumes a form comparable to that of an inverted cone with its lowest point at the well. As the pumping continues, this cone, called the cone of depression, continues to expand in area until the influence of the pumping has reached one or more of the boundaries of the aquifer. It can readily be seen, then, that during a period of drought, when the aquifer may not be recharged from exterior sources such as rainfall for a long period of time, exhaustion of the pumping area may occur. Such has been the experience of many municipalities depending upon limited well fields for their source of supply.

Surface Water

Municipalities which take their water from surface supplies feel an almost immediate effect from the cessation of rainfall and other means of continuation of flow, unless controls are applied. It is unfortunately true that in times of severe drought long periods of hot weather also occur, with an accompanying high rate of evaporation. Thus, the municipality which is dependent upon the natural flow of a stream finds its source of water supply rapidly dwindling until it consists of nothing more than a series of stagnant pools. The obvious remedy for such recurring situations is the storage of surface water in reservoirs during periods of high flow in order that it may be released when needed to replenish and maintain the natural flow of a stream. Therein lies the solution to the water supply problem of many communities. It is fortunate that Congress has recognized this fact in authorizing the multiple-purpose water resource development program of the Missouri Basin.

Recognition of the Problem

Recognition of the municipal water supply problem in the western states was brought forward in the Town-Site Act of 1906. At that time Congress authorized the Reclamation Service, which had been created in 1902, to consider supplying water for municipal purposes from irrigation projects. Under Sec. 4 of the act, provision was made to consider water rights for towns or cities on or in the immediate vicinity of irrigation projects. It was stated that such towns or cities were entitled to a water right from the same source as that of the project for the delivery of their water supply to some convenient point.

This subject was again covered in the act of February 25, 1920, which provided for furnishing a water supply for miscellaneous purposes in connection with reclamation projects. The act authorized the Secretary of the Interior, in connection with operations under the reclamation laws, to contract to supply water from any project irrigation system for purposes other than irrigation.

Finally, Section 9(a) of the Reclamation Project Act of 1939 recognized the municipal water problem as one to be solved by multiple-purpose water resource development. This act authorized the Secretary of the Interior to enter into contracts to furnish water for municipal supplies or miscellaneous purposes.

Coordination of Effort

The Missouri River Basin Project, authorized by the passage of the Flood Control Act of 1944, established a basic pattern for the development of water resources within that area.* Provision has been made to maintain a flexible program, so that it can be revised and reevaluated to meet the changing needs and the increasing understanding of the problem. The program is designed to provide the maximum benefit for the greatest number of Missouri Basin inhabitants through the coordination of water resource developments to produce irrigation, hydroelectric power, flood and silt control, recreational facilities and municipal and industrial water.

To attain the program's goal calls for a high degree of cooperative effort among all those concerned. Within

* Details of the project are given in Lewis A. Pick's article on "The Missouri River Development Program" in the July 1946 JOURNAL, Vol. 38, p. 859.

the Interior Dept. six other agencies are working with the Bureau of Reclamation to maintain a closely coordinated and effective schedule of development. These agencies are: the U.S. Geological Survey, the Fish and Wildlife Service, the National Park Service, the Bureau of Indian Affairs, the Bureau of Land Management and the Bureau of Mines. The Interior Dept. program for the Missouri Basin is coordinated by the Interior Missouri Basin Field Committee, through which each of the department's members is able to express the needs of his branch, so that the greatest possible contribution can be made to the over-all development plan.

The Flood Control Act of 1944 provided for the close coordination of the activities of the Bureau of Reclamation and the Corps of Engineers. Because the latter is principally interested in flood control and navigation development, while the Dept. of the Interior is concerned with the multiple-purpose resource development previously mentioned, a special need was recognized for the correlation of the activities of these two agencies. Working separately, yet with similar objectives, the Bureau of Reclamation and the Corps of Engineers presented to Congress in 1944 two plans for the development of the Missouri Basin (Sen. Doc. 191 and House Doc. 475, 78 Cong. 2). After extensive hearings by the Flood Control Committee of the House of Representatives the two plans were, at the direction of the committee, revised and coordinated by the Bureau of Reclamation and the Corps of Engineers. This revised, comprehensive plan for the development of the land and water resources of the Missouri Basin (Sen. Doc. 247, 78 Cong. 2) was approved by Congress in the Flood Control Act of 1944 and was signed by the President on December 22, 1944. The Missouri River Basin Project has as its aim the control and conservation of the waters of the Missouri River and its tributaries. It includes the utilization of these waters for the benefit of all the people of the basin. Irrigation; flood control; hydroelectric power development; improved navigation; silt control; domestic, municipal and industrial water supplies; fish and wildlife preservation; and the establishment of recreational areas are some of the benefits that will accrue to the people of the basin and to the nation from the development planned in the Missouri Basin Project.

A continuing correlation of the Missouri Basin program is achieved through the monthly meetings of the Missouri Basin Inter-Agency Committee. This committee consists of representatives from the Departments of the Interior, Agriculture, Commerce and the Army (Corps of Engineers), the Federal Power Commission and the governors of five of the ten states within the Missouri Basin. These five governors are selected by the ten-state Missouri River States Committee to represent that group at the monthly meetings of the Inter-Agency Committee. Governor Sam C. Ford of Montana is currently serving as chairman of the Missouri River States Committee as well as a representative on the Inter-Agency Committee.

Municipal Water Supply Program

The Dept. of the Interior has presented (Sen. Doc. 191, 78 Cong. 2) a broad plan for the conservation, control and use of water resources in the Missouri River Basin. Municipal water for at least twenty cities is provided for in the water development

plan. This reference to a specific number of cities does not mean to deny recognition to other municipalities within the Basin which are presently in need of new or supplemental water supplies or which may in the future have such requirements. In fact, the plan provides for the study of municipal water supply problems and for their inclusion in the over-all water resource development program. Preliminary basin-wide examination of the joint problems of domestic and industrial water supply and waste disposal indicates that these difficulties are widespread and that in some areas—such as the Sheyenne, Red and James River Basins of the eastern Dakotas—they are particularly acute. The treatment given to municipal water supply problems in Sen. Doc. 191 in no sense minimizes the importance of the existing needs of Missouri Basin towns. On the contrary, the brief consideration given by that document to a few outstanding problems serves to illustrate the necessity for providing safe and adequate domestic water supplies.

The lack of a dependable water supply presents a continuous and often threatening hazard to many communities throughout the Missouri Basin. Such a problem has a profoundly detrimental effect on the industrial development, health, manner of living and even the very existence of cities and towns short of water.

At present more than 40 municipalities are receiving water from projects constructed by the Bureau of Reclamation. The consideration of water rights on numerous streams has been involved, but it has always been possible to work out a plan for including the needs of the municipalities concerned. Municipalities currently holding contracts to receive water from Bureau of Reclamation projects are scattered throughout the seventeen western states. The circumstances under which these municipalities receive water and the reasons for their inclusion in the plan have been numerous and varied. Cognizance has been and is being taken of domestic and industrial needs in the water resources development plan of the Dept. of the Interior.

Conclusion

The solution to the problem of municipal water supply needs within the Missouri River Basin is not simple. Of the incorporated cities and towns in the northern portion of the Missouri Basin possessing municipal water systems, approximately 80 per cent draw their supplies from ground water sources. A large part of this group has faced serious water supply shortages, especially during drought periods. Many cities have already set forth their need for supplemental surface supplies. A more complete view of this problem can best be obtained with the cooperation of cities and towns throughout the basin. Every effort is being made to gain an understanding of these needs so that they may be incorporated into the comprehensive plan for water resource development throughout the basin states. Through the fulfillment of this plan will come the solution to the problem.

New Intake Installation at Kodak Park

By Allen C. Bailey

A paper presented on April 1, 1948, at the New York Section Meeting, Syracuse, N.Y., by Allen C. Bailey, Water Development Engr., Eastman Kodak Co., Kodak Park, Rochester, N.Y.

LOCATED in the city of Rochester, N.Y., is one of the divisions of the Eastman Kodak Co., known as Kodak Park. Approximately six miles to the north, on the shore of Lake Ontario, is a parcel of land and a group of buildings called the "Kodak Park Lake Station."

During the years 1917–18 a 42-in. Lock-Bar steel intake pipe, extending approximately $1\frac{1}{2}$ miles into Lake Ontario, was installed. The intake was buried in the bed of the lake and terminated in a wooden crib in 50 ft. of water. Because the capacity of the intake varied 1 mgd. with every 1-ft. change in the lake level, a "down" elbow was placed on the shore end in 1939. This gave a net 5-ft. increase in head on the intake by permitting a drop in the intake well water level, which resulted in a 5-mgd. rise in the intake's capacity. With the steady growth of water consumption, however, the old intake proved to have insufficient capacity to meet the demand, and in 1946 the installation of a new intake was completed. Work was started on the shore end in May and the line was finished in September 1946.

Intake Pipe

The intake is a reinforced concrete pipe, $5\frac{1}{2}$ in. thick with a 54-in. inside diameter. It is installed under the lake bottom, with a minimum cover of 2 ft., for a distance of $1\frac{1}{2}$ miles into Lake Ontario and terminates in a vertical "horn" fitting which is enclosed in a wooden crib set on the lake bottom in approximately 55 ft. of water.

The crib, which was made on shore and floated to the site, is 34 × 40 × 9 ft. (outside dimensions) with two 14 × 14-ft. sections for the "horns." It has two removable wooden plank-screen grilles, 14 × 14 ft., over each section. The grilles consist of 2 × 12-in. timbers set on 4-in. centers. The entire structure is surrounded by rock and concrete to protect it from dragging anchors and to hold it down.

Prior to starting any construction work, the contractor took soundings of the lake bottom along the entire line of the intake. This information, along with the elevations of the intake pipe, was plotted on profile paper to calculate the varying depths of excavation and insure the proper amount of cover over the entire line. Knowing the lake level, which was determined at the start of each day's operation, and the distance from the lake surface to the deck of the work scow, it was possible to measure accurately, by poling, the grade of the trench bottom at any point along the line, as well as the elevation of the top of the pipe itself.

The shore end of the intake is 15 ft. below grade and 11 ft. below the mean lake level. A steel-sheet coffer dam, approximately 40 ft. long and 10 ft.

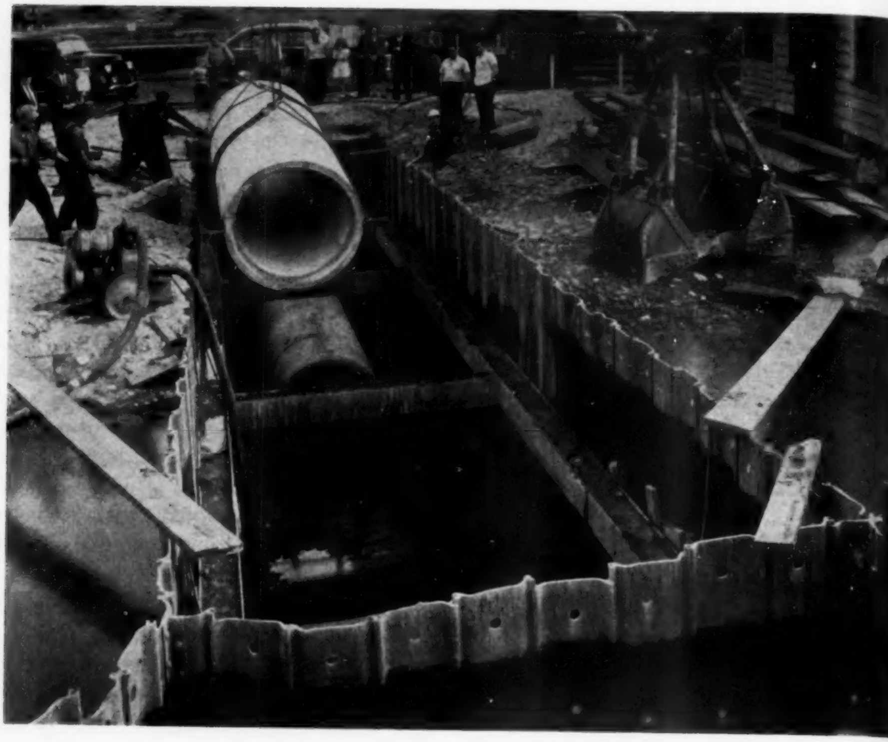

Fig. 1. Steel-Sheet Coffer Dam

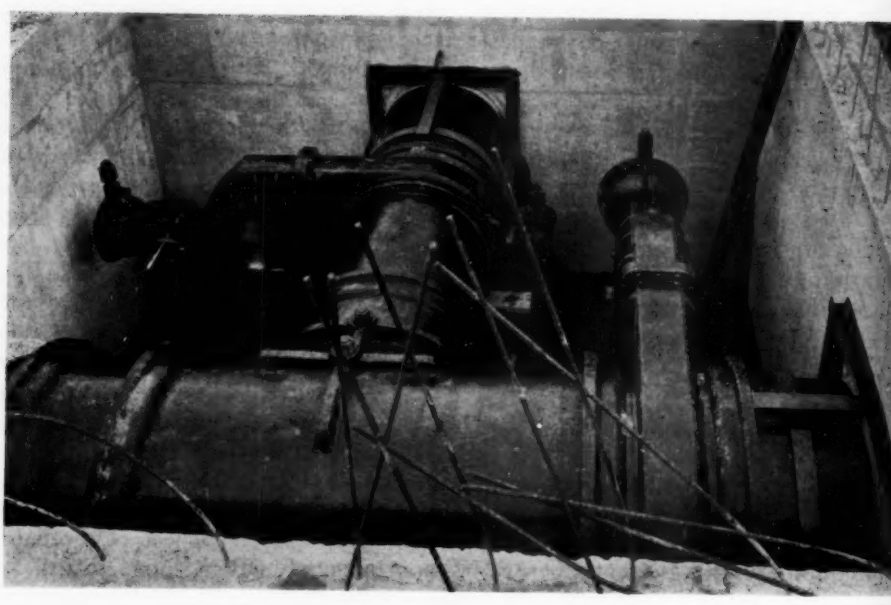

Fig. 2. Valve Sectionalizing Chamber

wide, was sunk at the junction of land and water (Fig. 1). The earth inside this dam was excavated, two pieces of 16-ft. pipe were installed and the ditch was backfilled; then the lake end of the dam was pulled and the trenching started. The trench was dug from the scow with a large clamshell bucket and was held level until its depth was 8 ft., at which point it began to take the grade of the lake bottom. The sides of the trench were sloped just enough to keep them from sliding in; this gave an average top width of approximately 20 ft. and a bottom width of approximately 8 ft. at a depth of 8 ft. Because of the sandy nature of the lake bottom and the currents along it, the trench tended to fill up rather fast, so that there was seldom more than 200 ft. of trench open ahead of the pipe.

Except for a few shore-end pieces, the pipe was put down in 32-ft. lengths by divers. The pipe had bell-and-spigot joints sealed by a rubber ring which was placed on the spigot end when the pipe arrived on barges at the work scow. The bell-and-spigot ends were then greased to facilitate the movement of the ring.

As each section of pipe went below the water surface, two divers guided it into the preceding section already installed. When they had the pipe joined, they would bind the two lengths together with tie bolts located on the spring line. This allowed movement in all directions but kept the joint from pulling out. The final length of pipe each day had a removable bulkhead put over its open end to prevent sand from getting into the line during further excavations or storms.

The marvel of the whole job was the crane operator on the work scow who, on instructions from the divers, would move the pipe up and down as little as $\frac{3}{4}$ in.

After the line was completely installed, the trench was backfilled and soundings retaken. The lake bottom did not vary more than ± 1 ft. from the original elevations. This was verified by the U.S. Corps of Engineers' surveyors who checked the lake bottom soon after the job was completed.

The pipe was made at Charlotte Harbor by the contracting company, which set up its own production facilities. Here the steel reinforcing coils were rolled on a large revolving mandrel, supporting strips were applied by welders and the finished forms were moved to the pouring area, where they were enclosed in vertical steel casings and concrete was poured around them.

The pipe was poured in 16-ft. lengths, each having a steel welding edge on one end and either a steel spigot or bell edge on the other. A 16-ft. length with the spigot end was welded to a 16-ft. length with the bell end, thus forming a 32-ft. length of bell-and-spigot concrete pipe. The space needed for the welding was then grouted inside and outside the shell to form a smooth surface and prevent corrosion. The 32-ft. pieces, weighing approximately 17 tons, were then taken to the curing site where they remained until needed.

Intake Well

The shore end of the intake, after going under a main highway, passes through a valve sectionalizing system (Fig. 2) and terminates in a 30-ft. diameter concrete well 40 ft. deep. This depth was necessary because the intake pipe turns downward, with the outlet about 30 ft. below mean lake level. This arrangement will make it possible to increase the head on the intake pipe, thereby enlarging its capacity, over gravity flow, by approximately 50 per cent.

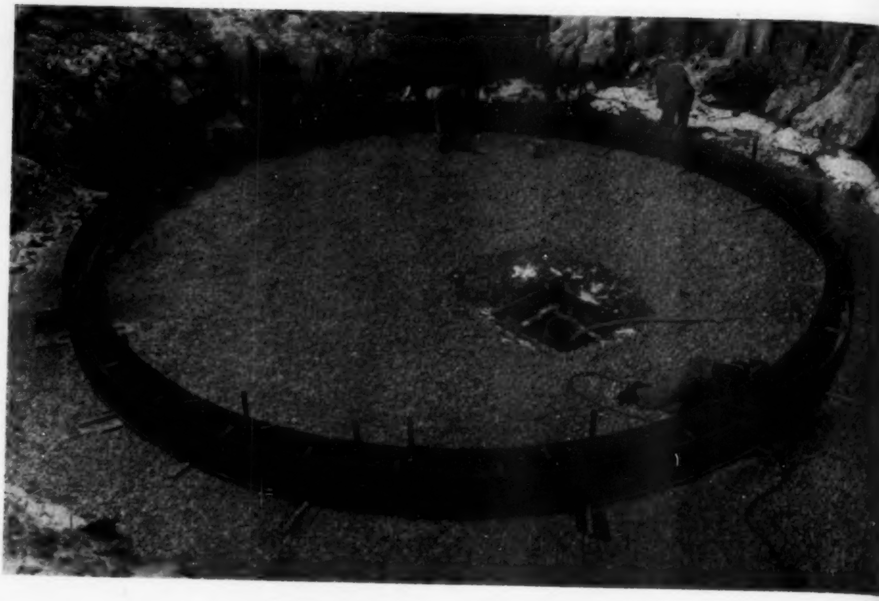

FIG. 3. Steel Shoe for Intake Well

FIG. 4. Intake Well Screen

The well is located just west of the present pumping station on the filled shore line of a near-by pond. A test hole showed that the soil was unstable and that rock was 40 ft. down. Under these conditions it was possible that the excavation of a large hole would affect the stability of the soil and might undermine the present pumping station.

It was decided to try the technique used in sinking caissons, thus eliminating the need for sheet piling, excessive excavation and soil disturbance. In January 1946 a large hole, about 50 ft. in diameter and 10 ft. deep, was dug at the location of the well. The bottom of the hole was covered with gravel and a sump pumphole excavated to take care of the ground water. Nature helped by freezing the sides of the excavation and keeping ground water seepage to a minimum. On the gravel base a steel ring 30 ft. in diameter was constructed with its underside tapered to form a cutting edge (Fig. 3). With this as a base, plywood forms were set up and the first section of the concrete shell was erected to a height of approximately 19 ft. Water jets in the form of 1½-in. pipe were installed in the concrete, extending down through the steel shoe. These were to be used against any stubborn soil that might be encountered.

The earth was excavated from the inside of the cylinder with a clamshell bucket and the cylinder started on its downward journey. When it reached a point 15 ft. below grade, the second section, 14 ft. high, was poured. This was enough to reach rock, after which the top section was poured. During the entire time the well was being sunk, the water jets were not used once. In fact, in one 24-hour period the cylinder settled 3 ft. During the sinking, the center of the well shifted only 2 in. to the north and 10 in. to the west of the original point.

The well is divided in such a way that, prior to arriving at the raw-water pumps, all the water passes through a traveling screen with ⅜-in. square openings (Fig. 4). This screen is in a well of its own, which can be isolated from the main well by 5 × 6-ft. sluice gates. An emergency sluice gate allows the by-passing of the screen well, so that water can be sent to the raw-water pumps while emergency repairs are being performed on the screen.

Raw-Water Pumps

The raw-water pumps are located in the south half of the intake well. At present there is only one 20-mgd. pump installed, although provision has been made for five.

The pump section was designed so that deep well turbine pumps could be used, thus saving building space. A novel feature is the requirement that the pump impeller and shaft be pulled from the operating floor level without breaking the discharge pipe connection. This is not a new design but was necessary because the discharge of the pumps is below the mean lake level and it was desired to be able to take any pump out of service for repair without shutting down the intake. The 42-in. discharge piping from the new intake pumps is connected to the 36-in. discharge piping from the old ones near the filtration plant. The connection was made under pressure by means of a 36 × 24-in. tapping sleeve and valve.

Abstracts of Water Works Literature

Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.—Bulletin of Hygiene* (*British*); *C.A.—Chemical Abstracts; Corr.—Corrosion; I.M.—Institute of Metals* (*British*); *P.H.E.A.—Public Health Engineering Abstracts; S.W.J.—Sewage Works Journal; W.P.R.—Water Pollution Research* (*British*).

PUMPS AND RELATED EQUIPMENT

Submersible Pumps. A. Linford. Civ. Eng. (Br.) **42**:386, 432 (Sept., Oct. '47). With advent of centrifugal pump for boreholes bucket-type pump became obsolete. Method of operating centrifugal pumps obviates suction- and foot-valve troubles. It is not ideal because: borehole must be reasonably straight, number of bearings required, if certain critical speed exceeded vibration occurs, bearings must be carefully aligned, grit in water will cause rapid wear of bearings, and wt. of shaft in deep borehole is great. Logical development to place both pump and elec. motor below lowest water level. This elims. long shaft, may be used in boreholes that are not straight, easily placed in position and raised for inspection, operation noiseless, floor space not required. Possible to assess condition of unit at any time by comparison of hydraulic and elec. readings with work's test results. Completely submerged unit depends on squirrel cage type of induction motor. There are number of "wet"-type motors: (1) totally enclosed and filled with oil, (2) enclosed in bell with bottom end open, (3) stator wound with ordinary wire and enclosure between stator and rotor preventing water from entering windings and (4) water allowed to circulate through waterproof windings to cool them and used as lubricant for bearings. First patent taken out in British Isles in '11 covering "wet"-type squirrel cage motor. After Armistice of '18 submersible salvage pumps used in raising scuttled German fleet. Submersible type of pump in many ways similar to surface centrifugal pump. Impeller rotates within diffuser with passages of predetermined shape. In normal design of radial flow impellers, value of specific speed (N_s) lies between 700 and 2000. Low specific speeds result in comparatively large diams. and passages of small width together with high friction losses. High specific speeds result in small diams. and, if too high, in unsatisfactory guidance of water. If motor designed to run at 3000 rpm. instead of 1500 not only is size of pump reduced but 4 times delivery head per stage can be obtained, whereas specific speed increased only 1.413 times. Max. efficiency can be obtained only with one particular set of delivery head and discharge conditions. Max. hp. should be developed at duty point to insure that sudden decrease in delivery head will not overload motor. Downward thrust on impellers large. To relieve lower thrust bearings, "balancing disc" fitted on rotating shaft on delivery side of top impeller and between it and top bearing. Full delivery pressure acting on it exceeds axial thrust on all impellers. Motor unit usually made readily detachable from pump. Pump bowls or casing made of cast iron or gunmetal. Wearing rings and bushes for bearings renewable and made of alloys such that no "seizing" can take place. Perhaps largest submersible pump unit mfd. of type 4 designed to lift 42,000 gph.(Imp.) against total head of 1030′ requiring 290 bhp.—*H. E. Babbitt.*

Genesis of a Pumping Station. Hal Wallhouse. Surveyor (Br.) **105**:363 (May 10, '46). Paper, slightly condensed, presented at summer meeting of Institution of Water Engrs. Proposal to construct pumping station and abstract water at Ruislip Common received authority in '39. Site chosen for well lies in valley of small tributary to River

Pinn flowing southward from Northwood Hills. Geologists had reported favorably on well site and yield of 2.5 mgd.(Imp.) was not overoptimistic estimate. Site was largely dictated by political necessities. Position chosen for 7′–8′ diam. well was fixed centrally with respect to 4 pumping bores with idea of constructing 4 independent pump houses and leaving well in open as means of access (to adits joining boreholes). Well was sunk through 37′ of clay, 25′ of Reading Beds and 213′ of Upper Chalk by percussion boring. Level of yield adit was fixed at 160′, 40′ above connecting adits and immediately below lowest aquifer. At 1,900′ from well small step faulting was seen in adit walls. There was little increase in inflow. It was deduced that adit had passed anticline. Driving was stopped and fresh tactics planned. Rhabdomancy tried. Possibility of using geophysical methods investigated. Decided to test predicted fissure by temporary 12″ bore to depth of 330′. Water found. Underground exploration next logical step. Expert advice obtained on adaptation of resistivity methods of survey, known as "electrical coring." Site was arranged on land adjacent to Poor's Field and new 5′-diam. well was completed to depth of 300′. Aquifers cut at 280′ confirmed measurements of electrical coring. Decision made to design treatment works on basic figure of 3.5 mgd.(Imp.); to include sterilization and softening to 140 ppm. Site conditions covered such factors as available means of disposing of waste water; type of removal of waste by-products; accessibility. Three softening methods studied were: sludge blanket lime softening tanks; oolitic lime softening towers; and hydrogen ion exchange. Decision was to adopt sludge blanket method because: (1) produced softened water of stable quality by means that permitted flexibility of operation; (2) provided treatment for 80% of total water as against only 55% and 50% in other two methods; (3) offered longer retention period of treated water because of higher percentage of treated water in blend and capacity of blend tank that follows sludge blanket tanks; (4) reduced waste water to minimum; (5) required only 43% of filter area necessary for oolitic method, and filters were required to remove only 5% of total carbonate as against 20% by filters following oolitic method; (6) cheapest in operational cost. In considering pressure and rapid gravity filters, advantages of pressure filters were: (1) complete salvage if resource diminished in quantity; (2) less costly to house; (3) easy to extend; (4) no algal difficulties; (5) flexibility of operational rates of flow. Advantages of gravity filter were: (1) visual inspection of water under treatment; (2) filter media more easily removed for cleaning; (3) little maintenance as compared with periodic painting of steel shells; (4) clean and interesting appearance. Choice of gravity filter was made. Reliance for main power supply was placed on grid (super-power line) and provision made for conducting 1000 kva. to common field. Alternative source of power seemed imperative as safeguard against steady increase in coal clause charges by elec. company. 600-hp. Diesel engine with blower to increase output to 900 hp. is to be installed. For sources of power to keep step in price coal must vary 5s per ton for every 1d per gal.(Imp.) variation in oil.—*H. E. Babbitt.*

Oil-Engine-Driven Pumping Plant. Dunswell Pumping Station of the Hull Corporation. C. Green. Wtr. & Wtr. Eng. (Br.) **51**:4, 56 (Jan., Feb. '48). Paper presented to Diesel Engine Users Assn. Plant of pumping station consists of 2 sets of 3-throw pumps, each with capacity of 5 mgd. (Imp.). Each set of pumps is driven by 6-cylinder, sleeve-valve engine. In calculating fuel consumption no deductions made for oil used for purposes other than pumping water. Fuel consumption has been exceptionally low and thermal efficiency correspondingly high. Mechanical efficiency at least 85%. Fuel consumption per water horsepower-hour appears to be unaffected by running plant load factor. Only 2 complete overhauls of each engine have taken place since they were first started in '32 during which time they have run together total of 95,760 hr. Since Nov. '39 there has been no need to shut down either engine owing to breakdown or defect. Cooling water drawn from main at 50°F. and returned to pumping well at about 100°F. Little trouble experienced from deposits although water has hardness of approx. 260 ppm. Engine costs per water horsepower-hour remain at comparatively low level mainly owing to efficiency and reliability of engines. (Fuel oil consumption close to 0.4 lb. per water hp-hr. for 11 yr.; lubricating oil consumption in '47 was about 0.66; and total engine costs in '46 were 0.7d per water hp-hr.). Maximum sleeve wear takes place at top of inside of sleeve where it works past junk rings in cylinder head. Small amount of wear and long life of crankshaft bearings due to con-

struction and materials used. No bearing has ever given trouble while running. Springhead, Mill Dam, and Dunswell Pumping Stations constitute 3 main stations of corporation. Springhead has 2 sets of triple-expansion steam engines and pumps; Mill Dam 3 sets. Approx. average water delivered daily from each station, in mgd. (Imp.): Springhead 5; Mill Dam 6.3; and Dunswell 5. (Data on costs are shown in table.) Running cost is, to certain extent, fixed charge as long as station in use and therefore varies inversely with quantity of water pumped. Essential for those who advocate use of oil engines to show that they will be reasonable in first cost and will possess qualities required in water works practice. Dunswell Sta. is most unsuitable building for housing plant because even when all machinery is stopped, dropping of spanner produces noise which rings through house. When installation of oil engine plant is contemplated manufacturers should be able to advise design of building to assure that engines will operate under advantageous conditions. Discussion centered on conditions that enabled engine to run with so little wear for nearly 1826 million revolutions. J. Arnall said: Type of built-up crankshaft, with easily removable crank pins, used in these engines permits using connecting rods with solid big-end eye, thus dispensing with big-end bolts. Bushings all of phosphor-bronze. Author said in conclusion: It is necessary that some method of stating rates of wear should be agreed upon, either relating wear to hours of running or revolutions performed.—*H. E. Babbitt.*

A Modern Pumping Station at Wendover, Bucks Water Board. Anon. Wtr. & Wtr. Eng. (Br.) **51**:18 (Jan. '48). Station located in "Wendover Gap" of Chilterns on northern edge of chalk escarpment. There are two interconnected wells, one inside building. It was first to be sunk. It is 7′ 6″ in diameter for first 60′ and 6′ in diameter for additional 80′. Adits are driven from well for distance of 400′ at depth of 110′ below enginehouse floor level. Second well, sunk in '44–'45, 190′ below floor level, with 24″-diameter bore going down 30′ further. Short adit was driven at 100′ depth, and lower adit, 140′ long, driven at 175′ depth. Water level varies considerably but is never less than 60′ below floor level. Brick pumping building is symmetrical in design. Well pumps and booster pumps installed in triplicate, each designed for 585 gpm.(Imp.) against 140′ head. Pump motors are 39 bhp. Boosters consist of 50-bhp. motors directly connected to 4-stage pumps delivering against head of 198′. Main reservoir into which pumps deliver is Ashendon Res., with top water level 30′ above enginehouse floor level. Second reservoir, Quainton Res., has top water level 125′ above enginehouse floor level. Although no bad samples have been taken, water is chlorinated with 0.25 ppm. and dechlorinated with SO_2, leaving residual of about 0.10 ppm. Water is cascaded to remove excess CO_2 and enters covered contact tank of 50,000 gal.(Imp.) capacity, giving chlorine contact time of about 45 min.—*H. E. Babbitt.*

Fighting Frazil Ice at a Water Works. John R. Baylis & H. H. Gerstein. Eng. News-Rec. **140**:562 (April 15, '48). Difficulties from frazil ice formations occurred at Chicago's South Dist. Filtration Plant during first two winters of operation when L. Michigan water was drawn through shore intake. Low-lift pumping capacity was often reduced seriously by frazil ice on impellers. To prevent such clogging, steam at 90–100 psi. is injected into pump sections so that water temp. is raised approximately 0.1°F., or just above critical range of frazil ice formation. In addition, ice on crib intake ports is removed by discharging dynamite in front of openings. On Jan. 29, '48, unusual ice plug in intake shaft of Wilson Ave. crib caused shutdown of all but 1 pump in 3 stations. Stoppage was blasted out with dynamite.—*Ed.*

Maintenance of Pumping Equipment. A. de Saedeleer. Tech. l'Eau (Belg.), p. 7 (Nov. '47). Maint. of centrifugal pumps in connection with valves, vents, horizontal and vertical vibrations, bearings, transmissions, motors and accessories.—*W. Rudolfs.*

Pump Output and Pump Priming. Edward Ingham. Wtr. & Wtr. Eng. (Br.) **50**:328 (July '47). Falling of pump output can be caused by change in condition of pipes brought about by corrosion. Increasing diam. of pump piping has marked effect in reducing frictional resistance. In numerous instances remarkable improvements have been made by replacing one or two sharp bends by others of larger radius. If new pump does not do duty, cause most likely fault in suction or delivery pipes. Suction pipe should be

large, short and direct. Strainer at submerged end offers great resistance. If distance between bottom of pipe and of sump restricted, water will be unable to flow into pipe. Importance of keeping air out cannot be too strongly stressed. Sluice valves should usually not be fitted in suction mains. —*H. E. Babbitt.*

Deep Well Pumps. M. A. Levy, L'Eau (Fr.) **34**:143 (Nov. '47). Study of different types of deep well pumps, their variations, installation, yields, operation, maint. and cost.—*W. Rudolfs.*

Fundamentals for Design and Construction of Siphon Conduits. Chr. Truelsen. Gas- u. Wasser. (Ger.) **88**:4:113 ('47). When water extracted from several wells by common siphon, wells should not be located parallel to ground water contours but so that pressure line parallel to static ground water slope through wells. Connecting pipeline should go into collecting pit which acts as sand collector, equalizes irregularities of pumpage and allows individual suction lines for each pump. Pipeline has to have uniform rise of from 0.2 to 1.0′ per 1000′ toward pit to elim. air pockets. This line should not go higher than pressure line 0.8–0.9 times atmospheric pressure above line of dynamic levels in wells and pit. If it should go higher, vertical drop has to be inserted. Not only starting, but continuous de-aeration needed for pipeline. This can be obtained by vacuum pump connected to vacuum tank or providing mixing device for air and water at top of vertical pipes which have to get high velocities. Pipeline has to be built carefully and tested for vacuum. It should not lose more than ½″ mercury vacuum in 12 hr. Each well should have separate valve between well and pipeline. Wells located 12′–16′ sideways from collecting line and connected to it by wyes. Pipe diams. detd. to give uniform slope of pressure line.—*Max Suter.*

STREAM POLLUTION CONTROL

Stream Pollution Abatement Standards Require Economic Justification. R. B. Wiley & W. E. Howland. Civ. Eng. **17**: 9 (Sept. '47). Poln. defined as unwarranted or unreasonable amt. of objectionable substances contributed to natural water of stream which, because of amt. and kind, should be removed, counteracted, or prevented from entering stream. Orders for treatment of wastes originating from public bodies must be issued in light of reason. Such orders may be reviewed by courts and their reasonableness would have to be sustained to be effective. There must be balance between cost of treatment and benefits received. Stream poln. abatement has many public health values. These are: (1) reduction to practical limits of load on water purif. plants and increased safety of water so treated, and (2) reduction in danger of spread of disease by: (a) swimming and wading; (b) cattle wading in streams, contamn. of their udders, and subsequent direct contamn. of milk in milking pail; (c) contamn. of wells along stream banks; (d) contamn. of legs and bodies of insects in floating and stranded filth and subsequent contamn. of food by insects; (e) contamn. of legs and bodies of water fowl swimming in pold. water and subsequent contamn. of drinking water in storage reservoirs; and (f) contamn. of fish, especially shellfish. Situations where proposed sewage or waste treatment programs should not be undertaken without careful balancing of all advantages and disadvantages are: (1) where public health only remotely involved and where money needed to build project probably would be taken from funds needed for schools and school teachers; (2) where qual. of stream water would be only slightly improved by proposed project; and (3) where removal of waste would result in removal of industry judged to be vital to prosperity of community. Stream stds. must be flexible and considered tentative. They are guides to judgment and should not become restraints to wise administration of water resources. Use of water will largely det. required cleanliness. Stds. may be prepd. for particular state on basis of (1) general recreational uses of water, (2) use as source of industrial water supply and (3) use for cultivation of fish.—*Sew. Wks. J.*

Disposal of Dairy Factory Wastes. J. A. Davis. Australian J. Dairy Technol. (Australia) **2**: 91 ('47). Rapid growth of dairy industry has led to increased accumulation of waste products from milk processing plants. Author makes comparative study of most satisfactory methods of waste disposal in his

own and other countries. Article includes diagrams and tables of various techniques employed in sewage treatment (diln., land treatment, biol. filtration, activated sludge process). Location of plant should det. method of disposal.—*C.A.*

Subsurface Disposal of Inland Oil-Field Brines. Ogden S. Jones. Civ. Eng. **17**: 2 (Feb. '47). Inland oil fields have much more difficult problem of oil-field brine disposal than do seaboard oil fields where disposal in ocean ordinarily practiced. Oil-field brines ordinarily have salt content of 6 times that found in sea water. Scarcity of fresh water in inland oil fields makes disposal by diln. generally impossible and also requires that disposal techniques protect existing fresh-water sources. Use of brine ponds has led to contamn. of shallow ground water which is frequently important source of water in areas concerned. Any person leasing his land for oil drilling purposes should insist upon proper brine disposal methods. In several Kansas areas brine has been returned to subsurface formations approx. 4500′ below surface. One disposal well drilled to this depth may serve as many as 60 oil wells. Another method of disposal—water flood—has been used successfully in Pennsylvania, as well as in Kansas and Oklahoma. By this method, return of brines to producing formation helps force out addnl. oil and, in addn., solves disposal problem.—*Sew. Wks. J.*

Successful Disposal Methods for Synthetic Rubber Waste. C. C. Ruchhoft, O. R. Placak & F. E. DeMartini. Civ. Eng. **17**: 2 (Feb. '47). Paper condensation of results obtained in lab. studies of rubber waste treatment. In synthetic rubber mfr. butadiene polymers and copolymers used. Butadiene and styrene have been used mostly in U.S. from alc. and petroleum fractions. Anals. given of typical wastes from synthetics of industry. Odor concn. reported reciprocal of diln. required to make odor just detectable. Initially studies made along conventional methods of water purif. to remove taste and odors caused by these wastes. Processes investigated were: coagulation, ozonation, addn. of activated carbon, free residual chlorination and aeration by diffusion and spraying. Coagulation and ozonation were of no value. Large doses of activated carbon, such as 100 ppm. or more, completely removed tastes and odors. Chlorination at break-point gave best results but for strong wastes was valueless. Aeration by diffusion produced some odor removal, with very effective results at 50°C. Treatment of these wastes should include removal of taste- and odor-producing systems as well as reduction of org. content. Activated sludge treatment gave 90% B.O.D. reduction in butadiene and styrene wastes under following conditions only: (1) that an aeration period of about 24 hr. be provided, (2) that no more than 25% of butadiene and/or styrene waste be fed with a good domestic sewage and (3) that sludge solids be maintd., in aeration mixt., preferably above 2000 ppm. Investigations showed that even with high B.O.D. removals high degree of removal of tastes and odors did not necessarily follow. Trickling filter treatment gave B.O.D. reduction of 90% for sewage and waste diln. and 86% for undild. waste. Odor concn. reduced from 750 to 16. Treatment of water pold. with activated sludge effluent investigated. 50 to 60 ppm. of activated carbon needed to remove taste and odor from diln. contg. 10% plant effluent and 90% tap water. Aeration, settling and coagulation of little practical benefit in reduction of tastes and odors from same mixt. Next logical step will be extension of these lab. expts. to pilot plant expts. No development along this line has yet occurred.—*Sew. Wks. J.*

Controlling Stream Pollution. George W. Reid. Southern Power and Ind. **66**: 1: 80 ('48). Some waste problems have been minimized by the recovery and sale of the material; this is true of cheese whey, which causes toxic conditions to develop during its decomposition. Other wastes may affect plants and plankton, on which fish feed; this is true of lime slurry. Change in acidity, temperature or osmotic concentration may also affect fish life, as well as toxic materials. Table given of the relative B.O.D. of various wastes at a concentration of 250 ppm. Brief resume given of several bills relative to waste disposal now pending in Congress.—*C.A.*

Influence of Wastes on Treatment and Use of Water. Charles F. Hauck. Chem. Eng. Progress **43**: 9, Trans. Am. Inst. Chem. Engrs. 481 ('47). Considers how and to what extent industrial waste poln. of public waters creates or aggravates water-use problems for communities or plants dependent thereon. Methods of minimizing, treating, utilizing and disposing of industrial waste waters not discussed.—*C.A.*

Pollution Abatement. Appraisal of Current Regulations. A. Anable & R. P. Kite. Chem. Eng. Progress **44**: 1: 3 ('48). Paper aims to establish factual background on anti-stream poln. legislation in U.S., its territories, and Canada as guide to chem. and allied processing industries in facing their waste disposal problems and formulating plans for their soln. Legislative aspects of waste disposal problem, as summarized, believed to be of paramount importance today as means of properly coordinating purely tech. and financial activities that must necessarily follow on broad front when industry recognizes long-range value of waste treatment to whole economy. Competition keen in modern industry, and treatment of industrial wastes, in all but a few isolated cases, can be regarded only as addnl. expense adding to cost of production, and either handicapping mfr. in his selling effort or reducing his margin of profit. Consequently, in dealing with tech. and financial aspects of poln. problem, there can be no incentive for reducing poln. effect of waste beyond point established by law and as administered by officials having jurisdiction over area directly concerned.—*C.A.*

Stream Pollution. David B. Lee & John C. Patterson. Florida Health Notes, **39**: 241 (Oct. '47). Authors define stream pollution; explain causes and effects on streams and natural bodies of water, in a very clear and simple manner. This is followed by explanation of need for pollution abatement in Florida. Specific problems are discussed, and plan of attack is presented. Principle causes of stream pollution are given as domestic sewage, citrus canning, pulp mill and meat-packing wastes, and phosphate ore washings. These wastes affect public water supplies, shellfish growing, and recreational areas. Program adopted by State Board of Health includes 3 steps: education and promotion, planning and executing general plant designs, and operation and maintenance of facilities. Mobile laboratory has been obtained to facilitate collection of specific data. Sanitary survey has been completed, and estimates of costs of needed municipal and community sanitary facilities are given. Paper pulp and phosphate industries have sponsored research projects to develop practical methods of waste treatment and disposal.—*P.H.E.A.*

The Sanitary Water Board and Its Relation to Public Water Supplies. J. Elliott Hale. J. Maine Water Utilities Assn. **23**: 74 (July '47). Article presents brief resume of Maine's water pollution laws. Sanitary Water Board's responsibility is outlined, and it is reported that the board has surveyed about 6000 mi. of rivers and streams. Most of streams surveyed are not used as public water supplies because they are already protected under Public Utilities Commission laws or under their own private and special laws. Maine's new antipollution law, Chapter 266, Public Laws of 1947, is given in its entirety.—*P.H.E.A.*

The Development of Water and Sewage Districts by Acts of the 1947 Legislature. J. Elliott Hale. J. Maine Water Utilities Assn. **23**: 79 (July '47). Article reports development of water and sewage districts which were chartered by 93rd Session of Maine Legislature. These include 10 sewer districts, 5 combined water and sewer districts, and 9 water districts. Districts indicate decided trend on part of people in these towns to improve sanitary conditions in their respective areas.—*P.H.E.A.*

Problems and Progress in Handling Stream Pollution Abatement in Connecticut. Warren J. Scott. J.N.E.W.W.A. **61**: 59 (Mar. '47). State agencies concerned with stream pollution abatement are Conn. State Dept. of Health and State Water Com. Brief comments are made on duties of each agency, citing laws under which each operates. Interstate Sanitation Com., comprising representatives of Conn., N.Y., and N.J., discussed. Compact is antipollution compact. Considerable progress has been made in sewage treatment. In recent months plans have been approved for sewage treatment plants for 9 communities. In addition, plans and specifications are in process of preparation for 15 communities. Treatment of many industrial wastes continues to be problem and great amount of research has been done by commission. Both Conn. agencies have worked out preliminary program of stream classification according to highest use, and discussions have been held with all state sanitary engineers of New England with view to classification of intrastate and interstate streams in New England area. It is believed that compact method affords states opportunity for dealing with pollution of waters, which is preferable to outright federal control.—*P.H.E.A.*

Sewage Disposal Practice in South Africa. E. J. Hamlin. Surveyor (Br.) **106**: 413 (Aug.

8, '47). Article explains conditions that contribute to need for individual approach in design of facilities for handling trade wastes, sanitary sewage and storm water in various parts of South Africa. Advantages derived from locating industries in terms of quality of wastes and accessibility to adequate facilities for disposal given. Rainfall and evaporation are cited as needing consideration for sewerage design. Practice of selling plant effluents for irrigation or of operating farms for obtaining useful advantage from effluent water explained. Crop farming, stock raising and tree-growing enterprises are cited as examples of productive advantage being obtained from water effluents from sewage plants.—*P.H.E.A.*

Sewage and Industrial Wastes to be Treated in Philadelphia [**Pa.**]. Sew. Wks. Eng. **18**: 576 (Nov. '47). Brief review of existing conditions in Schuylkill and Delaware Rivers. Pollution largely confined to these two rivers, as treatment facilities have already been provided for cities and industries located on tributaries. Practically all major industries on Schuylkill under orders from Sanitary Water Board to provide necessary treatment facilities. Many have already completed extensive treatment works. Major problem centers in disposal and treatment of municipal wastes for Philadelphia. Three treatment works of 125, 140, and 133 mgd. capacity planned.—*P.H.E.A.*

MILITARY WATER SUPPLIES

Water Is Life. Story of Water Supply in World War II. William J. Diamond. Military Engr. **39**:168, 211, 254, 330, 430, 527; **40**:6 (Apr.–June, Aug., Oct., Dec. '47; Jan. '48). *Chap. III. Final Organization of Water Supply.* War had come upon nation and period of preparation over. Each existing division had equipped water supply section attached to its engineer battalion, and equipment was being accumulated for additional units. Problem of finding water for troops and construction most pressing. As result, Strategic Intelligence Branch of Military Intelligence Div. of Office, Chief of Engrs., reorganized. Military Geological Unit required "to furnish detailed studies of existing sources of water and general geological features of country designated in each project; to prepare water supply maps showing these features, and to interpret these facts into specific recommendations for use of staff planners and task force commanders." Engr. Res. Unit translated foreign documents and periodicals and extracted and indexed water supply information they contained. Equipment problems: Equipment and units required materials that were critical and more vitally needed elsewhere. Substitute materials that were equally efficient and durable had to be discovered. Because enough filter alum could not be obtained new type produced that was almost as good. New type of rustproof lining for water tankers developed. Tests on well drilling rigs carried on by water supply section of desert test branch of Engr. Board in Yuma, Ariz., and Salton Sea, Calif., areas. *Chap. IV. Water Supply Troops Go Into Action.* To fit into general strategic plan water purification equipment operators in training at Engr. School specifically trained for conditions that would be encountered in Europe and Africa. Little intelligence available on water resources and their development in North Africa, and one course that was left was to build on information supplied by Strategic Intelligence Branch of Military Intelligence Div. As a result new type of water supply company with augmented personnel evolved. Water supply plan would serve 3 principal phases of North Africa operation: assault on specified beaches and reduction of all enemy forces in Algeria and Morocco; conversion of North Africa into advanced base for prosecution of campaign in Tunisia after surrender of French forces; and conversion of entire south shore of Mediterranean into base of operations for future campaigns against southern Europe after final destruction of all enemy forces in North Africa. In assault phase water was to be supplied from cleaned-out 55-gal. drums to be brought from England. They did not arrive until later so cleaned-out French wine tankers substituted. In second phase semipermanent water points installed in Morocco to serve permanent service units and occupation units. Casablanca municipal water system source of water points in city, and existing wells used or new ones dug in outlying towns. Area near Oran lacked streams and lakes, and well drilling rigs finally arrived in time. Field water points had to be established to serve combat troops in Tunisia. Water points kept on move when Germans struck until final offensive of Americans successful. When last of Germans and Italians had surrendered many water points discontinued and others made more efficient to

serve permanent bases. *Chap. V. Water Supply in the Persian Gulf Command.* To meet Russia's vital need for supplies in 1942 meant that supply of water to vast number of troops in Persian Gulf Command major problem. Water scarce commodity outside towns. Municipal systems in towns usually insufficient. These systems had to be rehabilitated and only way one water supply battalion available could do this job was to learn by doing. Work begun on municipal filtration plant of Khorramshahr. Water points needed were installed on municipal systems. There was a shortage of equipment in Iran. Any equipment that could be adapted to water purification or distribution requisitioned from civilian contractors operating in country. Last 6 mo. of 1943 and early part of 1944 busy days for water supply battalion. "Water systems of all towns with military occupants taken over and operated by production platoons. Pumping and purification equipment rehabilitated or expanded for greater output. In many cases new pumps sufficient to meet demand while in other instances major replacements necessary as well as redesign of plant layouts. Mobile units of battalion rarely incorporated into permanent water points. Instead they were kept in reserve and employed as temporary source during breakdowns or regular maintenance shutdowns." Well drilling section drilled 18 wells, with 12 producing. *Chap. VI. The Sicilian Campaign.* It was apparent at beginning that water supply and not enemy would be critical factor of operations in Sicily. This island always has had insufficient water. Plan of transporting water from Bizerte, North Africa, to beaches of Sicily studied. Strategic Intelligence branch of Office, Chief of Engrs., produced 4 volumes of engineer intelligence which "revealed that over-all water supply situation in Sicily had been greatly improved by 6-year plan of Italian government which had as its purpose increasing of available water supply of Sicilians to 30 gal. per capita." Older aqueducts had been repaired and many new ones had been built. There was sufficient water supply for civilian population and invasion force. As a precaution during early stages of landing, the 55-gal. drums that had served so well in North African invasion were steamed out, refilled with purified water, and loaded on invasion fleet. All of expected water sources found by invasion forces with little difficulty and developed quickly. Water points installed by leapfrog procedure as infantry advanced. Elements of division had to travel even farther to rear to obtain daily water requirements. This critical situation solved by rushing engineer troops to install additional water points, and water was tanked to forward dry distribution points. Extreme versatility of water supply battalion had been proved. After Messina had fallen water supply troops took part in conversion of Sicily into Island Base Squadron by installing permanent water points for it. *Chap. VII. Water Supply in Italy.* Strategic Engineer Studies of Salerno area and southern Italy indicated that few water supply difficulties should be expected. Water supply team would land with each combat team. Water points would be installed and operated as soon as troops had landed and were organized. Stiff German resistance encountered and campaign timetable obsolete. Because of this delay, packed-earth airfields had to be substituted. Heavy dust clouds raised by planes rendered them unusable until water tankers converted into road sprinklers for use on airstrips. Critical water situation for troops by this diversion of tankers averted by rushing water supply forces to beachhead. Retreating Germans destroyed Naples public supply, and people were drinking any water they could find—from gutters, polluted wells, and sewers. All military water supply equipment in use for troops. Very fortunately Naples' industrial water supply was undamaged. Filtration would be unnecessary; raw water could be pumped into tankers and hypochlorite powder added by hand. Water transported in canvas tanks on trucks from wet point to dry distribution points for civilian population. Situation was saved. Public water supply aqueducts and other damaged portions repaired as soon as possible. Emergency demands for water were made from time to time upon water supply forces in and about Naples, including water for locomotives and electric generator cooling water, and water to put out fires caused by German time bombs. On Southern Front water points dismantled or installed to meet new conditions. Special water supply tasks included: "installation and maintenance of semi-permanent systems at evacuation hospitals located in Corps and Army area and their movement when hospitals advanced; tanking water to hospitals, bakeries and other large consumers; and installation and operation of dry distribution points in areas with scanty supplies." Conditions critical during rainy

season when clear streams became muddy torrents and portable units unable to clarify them. Additional equipment and organizational changes stabilized water supply situation. In Anzio landing water points operated satisfactorily and soon became stationary and highly developed. Preparations made for advance on Rome. When main supply road obscured at night by heavy dust clouds tank trucks of water supply company equipped with special road-spraying attachments. After 3 days of heavy fighting German line broken and water points in constant motion leapfrogging all other points. "As entire army moved forward toward capture of Rome, elaborate plans made for supplying civilians with water if necessary," but there was lack of destruction. As troops fought their way into Apennine Mountains behind Florence water supply situation became terrible. Some divisions were stopped in area of no water sources and water had to be brought by long haul. Well drilling efforts futile. Weather and road conditions became worse. Sufficient number of dry distribution points operated successfully during remainder of winter under hazardous conditions. "In previous stalemate at Cassino, production platoons of water supply companies learned several lessons:—presedimentation absolutely necessary during rainy season; turn-arounds at water points had to be graveled if vehicles of consumers were to obtain water. Application of these principles and use of springs wherever possible kept steady stream of water flowing to division dry points and retail consumers of Corps area until temperature decreased to freezing point. Then new problems presented themselves; distribution lines, pumps and units frequently frozen after lying idle throughout night; hospital installations froze up continually. Combination of many devices solved problem. Portable units and pumps were housed in tents or buildings; water was allowed to trickle through distribution systems at all times and the pipe and hose itself was reduced to a minimum and insulated as much as possible with burlap bags; winterized water system was devised for hospitals and other large consumers consisting of an enclosed water tower, immersion water heaters, insulated pipe and housing of all outlets in heated tents." With all precautions taken, water supply troops were able to fulfill their mission during winter of 1944–45. Offensive in spring slowly gained momentum. Bologna fell and within few hours water points were supplying civilians with water, their water system having been partially destroyed. As offensive gained momentum German retreat became rout and somehow water points were kept up with advance. Influx of prisoners of war for a while was unmanageable problem for water supply companies. With end of the Italian Campaign all water supply battalions inactivated and separate water supply companies formed. *Chap. VIII. On the Western Front.* Allied High Command (and German General Staff) had concluded as early as 1942 that only in France and Lowlands would German Army stand and fight. When general tactical plans for cross-channel invasion approved water supply plans developed. "Strategic Engineer Studies had been prepared on all countries of western Europe and they included every bit of information that could be of value to water supply engineers. Study on France particularly informative. It described in detail water system of every town in France with population greater than 10,000; quantity and quality of raw water which was available; type and all other details of treatment plant; number, kind, and capacity of reservoirs; type of power used in operation of plant; all information on pipe system; civilian demand; and all other related information necessary to give engineer complete picture of municipal system. All natural sources of water—rivers, streams, springs, and wells—accurately located on water supply maps. Possible sources of ground water revealed in complete geological maps and informative text on geology of France." Water supply plan of SHAEF Engr. elaboration of 5 basic elements: training for operation, assault and development of Logemont area, exploitation of Logemont area, organization of communications zone and rehabilitation of municipal facilities. Planning, training, and rehearsals lengthened into years. On D-day assault troops went across beaches with filled canteens. They were accompanied by engineer reconnaissance parties to locate water sources from which to refill them. Bulk water supplies and portable units soon were on the beaches. Area relatively undeveloped. Streams of beach area not desirable because of brown color imparted by peat soil. After Logemont area had been secured water supply troops moved their installations well forward and mobilized for instant movement. Germans retreated and surrendered Paris. In both Etain and Metz water supplies damaged and had to be rehabilitated. Throughout

fall of 1944 water supply units encountered few difficulties. Water plentiful and of relatively good quality. Many municipal supplies captured intact because Germans did not have time for demolition. When streams became muddy because of fall rains water supply situation became chaotic. Immediate action necessary to redesign water points for presedimentation. In December "disaster averted by thoughtful planning before first freeze. Higher headquarters ordered all their subordinate units to prepare for freezing weather. All ideas and plans for winter operations were freely interchanged between units. Action followed planning:—Anti-freeze added to all pump cooling systems; provisions made to drain all pumps and dispensing systems at completion of each day's operation; water points in open locations were either moved to sheltered sites or a shelter was constructed over equipment on old site; stoves installed in mobile units and allotment of coal secured; some equipment modified, such as replacement of venturi tube on hypochlorinator with simple feed apparatus; bases of filters insulated, maintenance improved; thermometers purchased from French sources; G-2 initiated system of weather forecasting for prior information to water supply units." Third critical situation scarcity of filter sand. Too many operators had washed their filters too vigorously. Situation remedied by grading several tons of sand by hand with 16- and 24-mesh fly screening. Replacements for tankers scarce, so tanker bodies taken from old trucks to new trucks. Liquid chlorine for mobile units had to be conserved. With victory, water supply units began preparation for either occupation duty or redeployment. Some departed either for United States or the Pacific. Those that remained spread their operations over vacated areas and water points became more elaborate and greater efficiency with less personnel obtained to serve the increased areas of operation. *Chap. IX. In the Pacific Theaters.* Decision of Chiefs of Staff was that war in Europe was to be prosecuted to fullest extent, even to detriment of other theaters. Odds against adequate water supply organization for Southwest Pacific Area enormous. Personnel and equipment of water supply sections pitifully inadequate. Water supply operators were few and untrained in operation of distillation equipment, which was water supply weapon of Pacific. Equipment insufficient even for initial authorization. Strategic Intelligence Branch would have to complete most of its studies on Europe, a matter of 2 yr., before it could work on Southwest Pacific Area. Distillation equipment inefficient and antiquated. Fortunately large number of purification units, surplus from Australia, found. These units employed diatomaceous earth instead of sand as filtering medium, and Australians claimed they were better for purifying highly contaminated waters of Pacific than American portable units. These claims soon were proved by demonstrations. "Programs were developed for training in operation and maintenance of diatomaceous earth filtration units, distillation units, and purification methods applicable to operations in Pacific." Pacific island campaigns. South Pacific Area organized to meet encroachment of Japanese forces in Solomon Islands where they dominated supply lines from United States to Australia. To strike first blow Combat Marines landed on Guadalcanal with filled canteens. There were water supply difficulties at once. Distillation units installed. Distribution of water produced to dispersed troops in impenetrable jungles never solved adequately. "Some solutions which minimized problem were: development of methods by most individuals for catching rain water and morning dew for washing and, in case of necessity, drinking; securing of excess equipment and dispersion of water points to greatest possible extent, even going so far as to install distillation equipment on fresh water sources to keep all units in operation; and strict water discipline to conserve supplies. Despite all efforts, water supply throughout Guadalcanal operation in precarious state and there was little that could be done to improve it." In attack on New Georgia group at Munda landing fiercely resisted. No water supply equipment had been brought, and troops soon exhausted their supply. Drinking water obtained from shell hole that had filled with fresh water from some ground water source. Finally equipment arrived which produced 10,000 gal. of water a day. Situation deteriorated steadily when more troops arrived, until a dug well captured. Several times a day sources pumped dry, and operations had to be suspended while nature replaced them. Water situation during attack on Bougainville more satisfactory. Lessons learned: There was improvement in technique and service but prevailing conditions limited it. Water supply personnel who were assigned were completely ignorant of operation of distillation equipment and

had to be trained in distillation school in Hawaii. Either training inadequate or pupils inept because they were cause of many critical water supply situations. "Water supply personnel of Marine Corps experts in operation of distillation equipment due to excellent distillation schools operated at Quantico and Pendleton. At all times, Marines secured maximum from their equipment and had little difficulty keeping it in operating condition. Seabees, supplying water to naval installations throughout the Pacific, likewise were well trained in principles and use of distillation equipment." All types of purification equipment operated by Combat Engrs.: portable units, distillation equipment, hypochlorinators, gas chlorinators, and mobile purification units. "In practically all operations, and particularly during the garrison period, Marines and Seabees more adequately equipped than Army units." Enemy action caused heavy casualties to personnel and damage to equipment at water points. In every operation it was necessary to protect them either by infantry or additional personnel from engineer battalion. Municipal water supply facilities were scarce in most islands of central Pacific. Most of Japanese-built supplies destroyed either by attackers or attacked. Actual distances between units were small, but it was necessary to transport water over very long distances, so there was little coordination and interdependence of water points during combat phases of any landing. "In all landings troops went ashore with 2 and sometimes 3 full canteens. Second source was water unused by fallen buddies. Third echelon of water supply was bulk containers that accompanied invasion fleet. After capture of first island of an atoll, lighters equipped with tanks frequently used to supply troops in subsequent operations against remainder of atoll. Most of initial sources were sheltered nooks beside ocean where distillation units installed. It was soon determined that salt water of wells farther inland less salty and as soon as possible distillation equipment moved to such sources. On some of islands, no fresh water sources found and distillation equipment used throughout the assault and occupation of island. On some islands it was discovered that wells could be drilled or dug to sea level and layer of fresh water would be found floating upon sea water. By judicious pumping it could be secured with little or no contamination by salt water. Many wells were in existence throughout Pacific, but frequently their use was forbidden because of their insanitary condition. During assault phase of all operations, there was little development of water sources because of their lack of permanency. After islands were secured and garrison phase began, water points were highly developed." *Chap. X. On to the Philippines.* For first time, everything for water supply operation adequate or better. Strategic Engr. Studies revealed that water supply problem would not be serious in any of islands. The Bureau of Public Health had drilled numerous wells in Luzon. Water supply organizations sufficient to organize 4 echelons. In assault landing on Leyte all of necessary water sources for divisional water points located. Reconnaissance continued and many wells driven by jet method. Similar predesignated operations carried on during other island landings. Water supply on Luzon continued to be excellent up to gates of Manila. Japanese began systematic destruction of Manila's water supply. Some destruction accomplished and some prevented. Within section of city without water 10 mobile purification units and 30 distribution points set up. Civilians adequately supplied with water and there was no decrease of it for troops. "In capture of Corregidor, water supply one of most critical problems. Finally, two LCM's were fitted with Navy cells and these were filled on mainland. In addition to this water ship, distillation equipment accompanied invasion fleet. Water ship dispensed water while distillation equipment being installed and water plentiful first day. That night Japanese suicide demolition soldiers blew up equipment and themselves. More equipment brought from the mainland. No more suiciders showed up and water supply situation again normal." After other islands cleared water supply organizations made ready to go to Japan. War in Europe ended, and water supply organizations of that theater were on their way to the Philippines when Japanese surrendered.—*P.H.E.A.*

Water Equipment for the Arctic. CHAUNCY W. KARSTENS. Military Engr. **39**:420 (Oct. '47). During U.S. Army's operations in Arctic Zone to determine usefulness and adaptability of standard army equipment there, supply of potable water was one of greatest problems encountered. Two 50-gph. and two 500-gph. ice and snow melters procured for experimental and test purposes by Engr. Board. Mounted on skid-type base, with hardwood runners, each of these

units consisted essentially of inner melting chamber, multipass horizontal fire tube type combustion chamber, and outer water jacket insulated with 2″ thick layer of magnesia block and covered with light metal jacket. Melting and combustion chambers and water jacket made of stainless steel. Circulation between inner chamber and water jacket accomplished by means of recirculating tubes passing through combustion chamber. Circular gasoline burners of pressure atomizing-vaporizing type. 50-gph. unit provided with single burner and 2 fuel tanks of 7½-gal. capacity each. It measures 77″ long, 39″ wide, 42″ high, and weighs 907 lb. 500-gph. unit, provided with 3 burners and 3 fuel tanks, is slightly larger and weighs 1440 lb. When operated in test chamber, 500-gph. units at −50°F. melted ice at rate of 75.75 gph., with discharge water temperature of 60°F. Gasoline consumption was 1.27 gph. Over-all heat-transfer efficiency was 63.5% at maximum burning rate. Ice and snow can be fed manually about 630 lb. per hr. Results of service tests in Far North indicate these units essential; but simplified, improved and more rugged equipment necessary. Winterized water purification plant has been designed, fabricated and tested in laboratories of Engr. Board. Heavily insulated skid-mounted shelter contains modified 50-gpm. diatomite filter and necessary accessories. Over-all dimensions 8′ by 16′ by 9′ high, weighing about 6100 lb. Water pump and hypochlorinator are electric motor-driven with power supplied by 5-kw. generator, gasoline-operated, installed in shelter. Heat provided by air circulated through engine radiator. Exhaust blower in generator room provides forced circulation to exhaust gases from engine. Three hose connections: influent for raw water; waste for wash and drain; and discharge for transporting carrier. Standard ordnance 250-gal. water tank trailer has been modified and winterized to treat, filter and distribute water at extremely low temperatures. Compartment has been fabricated at rear of tank to hold Vapor-Car engine coolant-type gasoline-burning heater, 2 Berkfeld-type filters, necessary interconnecting pipe and hand-operated pump. Tank and compartment heavily insulated with fiberglass mat covered with sheet aluminum. Entire unit can be mounted on wheels or on skis.—*P.H.E.A.*

Water Supply for the Air Transport Command. Fred E. Smith. J.N.E.W.W.A. **61**:238 (Sept. '47). Various problems encountered in providing adequate water supply at Air Transport Command bases described. Existing municipal surface supplies utilized almost exclusively in United Kindgom and France. Water transported by trucks and chlorinated in Lister bags at original Brussels base. In Rome, new supply provided using springs as source. Collecting galleries served as source of supply in Naples. These supplies were chlorinated. German supplies were from deep wells. African supplies were from ground or surface sources and were chlorinated prior to use. Distilled water was used as source of supply at Dhahran, Saudi Arabia. Chlorinated ground water supplies were utilized at Karachi and Calcutta, India. —*P.H.E.A.*

Chemical Purification of Water in [Military] Campaigns. Lúcio Muniz Barretto. Arquiv. Inst. Biol. Exército (Arg.) **7**:207 ('46). Procedures involving ozone, oxygen, permanganate, I, Br, $NaHSO_4$, org. acids such as citric and tartaric, alum and Na_2CO_3, Ag and Cu, and Cl and its derivatives described. Latter group, including Cl, hypochlorites and chloramines, considered best and 2 procedures described for use where commercial equip. not available.—*C.A.*

ANNUAL REPORTS

Long Beach (Calif.) Water Dept. Annual Report (Year Ending June 30, 1947.) Five-man board appointed, one each year, by city manager and approved by city council. Estimated population 265,000. Water consumption 103.7 gpd. per capita. Distribution system 535 miles, 3728 hydrants, 49,875 services, 100% metered. Well supply 67%, Colorado River 33%; electric pumps deliver water to system and 40 mil.gal. storage in 12 steel tanks. Gross income $1,651,894. Net after deducting depreciation $587,612. Operating and general expense $856,332, depreciation $207,829, interest $67,408. Bonds outstanding $1,430,000, depreciation value of plant $10,518,871, cash reserve fund $215,454, stores $37,695. Invested funds $501,453. Survey and report for needs for next 25 years was completed. Plans for 25-mgd. treatment plant for well supply was approved and some contracts awarded.—*O. R. Elting.*

Hartford (Conn.) Metropolitan District Water Bureau. Annual Report (Year Ending Dec.

31, 1946). Organized in '29. District includes Hartford and 7 adjoining municipalities. Estimated pop. served 309,000; consumption: maximum 7-day 31.24; maximum month 29.61 mgd.; yearly average 30.31 mgd. Gravity supply. Distribution of revenue dollar: supply 5.2¢, purification 3.6¢, distribution 9.9¢, accounting 3.5¢, administration 15.2¢, taxes 1.7¢, depreciation 16.3¢, fixed charges 43.6¢, surplus 1.0¢. Distribution system 629 mi., 40,017 services (39,183 metered) and 4070 hydrants. Gross revenue $1,717,190. Operating expense $685,811. Fixed capital $31,426,128; bonded debt $9,504,000; net worth $14,102,435. Consumption in excess of 30 mgd. occurred on 151 days as against 71 days in '45.—*O. R. Elting.*

Oak Park (Ill.) Water Dept. Annual Report (1947). Water purchased from city of Chicago on metered basis delivered to village through five 12" meters. Three other connections assure protection as to supply. Pump station houses 8 motor-driven pumps, combined capacity of 24 mgd. boosting pressures an average of 25 psi. Storage reservoir 5 mil.gal. Estimated population 70,000, daily consumption 6.06 mil.gal. 107.4 mi. of mains supply 12,162 meters and 1126 hydrants. System 100% metered, water sold 89.7% of total. Total income $468,729; expense: purchase of water $164,221; operating and maintenance $101,366; interest $1075; depreciation $37,333; transferred to city funds $132,000; net gain $32,734. Fixed assets original $1,268,069; less depreciation $182,524; current assets $340,969. Liabilities: bonds and deposit funds $43,045. Net worth (assets over liabilities) $515,886. National Board of Fire Underwriters recommended construction of 1-mil.gal. elevated tank.—*O. R. Elting.*

Des Moines (Iowa) Water Works. Annual Report (1947). Operates under 5-man board of trustees. Pop. 184,641, consumption 20.52 mgd. or 111.1 gal./capita. Water under pressure of 38–118 psi. delivered through 444 mi. of 4–36" mains (68%, 8") to 3809 hydrants and 43,372 services, 99.6% metered. Metered services billed for 79% of water pumped. Gross income $1,197,462; operation and maint. $562,870, depreciation $129,991, interest and sinking fund $291,830, invested capital $212,771. Plant—less depreciation—$7,547,213; total assets $9,233,788. City's equity $5,676,028. Pumping: max. 45.4 mgd.; min. 8.2 mgd.; avg. 20.52 mgd. Coal 17.1% ash, 9138 Btu. as fired. Evapn. ratio 5.70, boiler and stoker eff. 68.7%, station steam duty 118.0, over-all thermal eff. 9.51%. Rainfall 43.04" (11.00" above normal), air temp. avg. 51°, max. 90°, min. 0°F.; water temp. avg. 55°, max. 72°, min. 42°F.—*O. R. Elting.*

Louisville (Ky.) Water Co. Annual Report (Year Ending Dec. 31, 1947). Company owned by city and operated by board. Estimated pop. 400,000. Ohio R. water pumped to reservoir and repumped after purification. Consumption 57.73 mgd.; 781 mi. of mains; 81,066 services, 100% metered; 3824 hydrants. Operating income $0.100; expense $0.053 per 1,000 gal. Revenue $2,927,482; net profit $1,303,575; fixed capital $24,667,086. Funded debt $404,000, due '50. Funds to balance total requirement for retirement of issue voted from '46 income. Company is in fact debt-free. Contract awarded for electrification of Cresent Hill Pumping Sta. Billing of sewer rental charge with company acting as agent for sewer district was started. Underground water survey by U.S.G.S. continued, report due in spring of '48. 87 breaks in distribution system, 46 in Feb., 22 in Dec. Filtered water storage 57 mil.gal. Pump capacity 230 mgd. raw water, 152 mgd. filtered water.—*O. R. Elting.*

Wyandotte (Mich.). 54th Annual Report (Year Ending Sept. 30, 1947). Pop. 32,000. Munic. Service Com., appointed by mayor and confirmed by council, comprises 5-man board operating electric and water utilities. Water Div. revenue $181,348, net income $28,817 after deducting all charges including depreciation. Depreciated plant $1,268,101, investments $300,919. Debt $442,919; city equity $1,214,371. Expense: percentage—pumping 11.1, purification 18.4, distribution 23.7, office and administration 5.8, interest 10.7, other expense 15.8, surplus 14.5. Operating revenue $21.49 per customer. Population 38,000. Consumption 4.14 mgd. or 109 gpd. per capita, max. rate 8.5 mgd. Plant: six 1-mgd. rapid sand filters, 1.4-mil.gal. underground and 0.5-mil.gal. elevated storage. Pump capacity 14.8 mgd. Distribution system 92.8 miles of mains, 757 hydrants, 7,995 services. 73.3% water delivered to meters.—*O. R. Elting.*